United States Environmental Protection Agency
Region 2

DRAFT – MANAGEMENT REVIEW COPY

NATIONAL REMEDY REVIEW BOARD BRIEFING PACKAGE

LOWER PASSAIC RIVER RESTORATION PROJECT

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DRAFT NRRB BRIEFING PACKAGE

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A. NRRB BRIEFING PACKAGE SUMMARY

A.1 SITE SUMMARY

A.1.1 Site Name and Location

The Lower Passaic River Restoration Project ("the Study") is a comprehensive study of the 17-mile tidal portion of the Passaic River and its approximately 118 square-mile watershed (hereinafter referred to as the Study Area) in northern New Jersey. The 17-mile tidal portion of the Lower Passaic River is an operable unit of the Diamond Alkali Superfund Site in Newark, New Jersey. During the course of the Study, sediments in the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. Through a risk assessment and Focused Feasibility Study [FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] conducted to comparatively analyze remedial alternatives, a Source Control Early Action is being evaluated to address these contaminated sediments in the lower eight miles of the Passaic River (hereinafter referred to as the Area of Focus). The Source Control Early Action, which will be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is on-going.

A.1.2 Superfund Site Identification Number

The Superfund Site Identification Number for the Diamond Alkali Superfund Site is NJD980528996.

A.1.3 Operational History and Contaminants Present

The Lower Passaic River has a long history of industrialization. During the 1800s, the Lower Passaic River watershed was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around Great Falls in Paterson. In subsequent years, many industrial operations developed along the banks of the Passaic River, including manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Direct and indirect discharges from various facilities have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Furthermore, the Lower Passaic River has received direct and indirect municipal discharges from the middle of the nineteenth century to the present time. Together, these waste streams (industrial and municipal) discharged many contaminants, including dioxins, petroleum hydrocarbons, polychlorinated biphenyls (PCB), pesticides, and metals to the Lower Passaic River, all of which adsorb to fine-grained sediments and bioaccumulate into fish and shellfish.

The Superfund program history of the site started with the listing of the Diamond Alkali Superfund Site to the National Priority List (NPL) in 1984. At the time, the site was confined to the upland area of 80-120 Lister Avenue facility in Newark, New Jersey, and the main contaminant of concern was 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD). In 1994, the six-mile stretch of the Passaic River in front of 80-120 Lister Avenue was designated another Operable Unit of the Diamond Alkali Superfund Site. In 2003, a Remedial Investigation/Feasibility Study (RI/FS) for the six-mile stretch was halted, and the study was expanded to the 17-mile stretch of the Passaic River (also known as the Lower Passaic River), while the list of contaminants was expanded to include PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs) and metals. In 2004, Newark Bay was designated yet another Operable Unit of the Diamond Alkali Superfund Site, and a separate RI/FS initiated.

A.1.4 Key Features of the Site and the Surrounding Area

An important component of the region's historical development and urbanization was the deepening of the river to permit commercial navigation into the city of Newark and farther upriver. Several large dredging projects at the beginning of the twentieth century established and maintained a navigation channel through more than 15 miles of the river north of Newark Bay. Since the 1940s, there has been little maintenance dredging above river mile (RM) 2 and none since the early 1980s. Consequently, extensive fine-grained sediment deposits exist in the channel, particularly between RM0 and RM8. The coincidence of contaminant discharges to the river and a significant suspended sediment load created an ideal situation for accumulating contaminated sediments. As a result, the river accumulated substantial sediment beds, measuring up to 25 feet thick in some areas. These thick sediment deposits remain, primarily below RM8 where the relatively wider river channel provided favorable conditions for rapid sediment accumulation.

Analysis of recent bathymetric data indicates that the river section RM0 to RM2 represents a depositional segment of the river with sedimentation rates greater than 2.5 inches/year over the last 18 years. For this section, the low ratio of the volume of resuspended sediments to the volume of gross deposition (less than 5%) demonstrates that most of the solids in this section originate either from Newark Bay or upstream. Bathymetric data for RM2 to RM14.5 indicate this section of the river is a dynamic, minimally depositional to erosional section. The sedimentation rates in this section range from -0.33 to 0.35 inches/year, with an annual rate of sediment accumulation of roughly one quarter of an inch per year. The net volume of sediments deposited annually in this river section is comparable to the volume of sediments eroded from this section, indicating that both resuspended solids as well as new solids contribute the gross accumulation of solids in this reach. Based on year-to-year bathymetric surveys, it is estimated that the volume of solids annually resuspended is equal to or greater than the annual net accumulation.

Analysis of bathymetric data collected over an eighteen year period suggests that the river between RM2 and RM14.5 has reached a "steady state" with respect to net deposition, with little net change in the average river bed elevation over time (*i.e.*, roughly one quarter inch per year) While there are areas primarily subject to erosion and deposition over time, most areas are subject to both processes, with sediment loss and accumulation occurring over shorter time intervals. The routine variation of depositional and erosional conditions reflects the influence of flood events and tidal mixing, which have served to distributed sediment contamination throughout the Lower Passaic River as well as into Newark Bay and the New York – New Jersey Harbor Estuary.

Sediment contaminant concentrations are even greater in deeper sediments than at the surface. The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cubic yards (cy) (USEPA, 2002c) and Fox River PCB site at 8 million cy (USEPA, 2003b)], but these inventories are spread over much greater distances than the eight miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cy for RM0.9 to RM7.

Sediment erosion due to the back-and-forth motion of the tides and storm events is most likely responsible for continuing releases of contaminants from the river bed. As a fraction of all of the solids sources to the Lower Passaic, resuspension of deeper sediments comprises about 10 percent of the total annual deposition. However, resuspension accounts for over 95 percent of the dioxin accumulating on the river bottom, and at least 40 percent of the accumulation of PCBs, pesticides, and mercury. Resuspension of legacy sediment accounts for 10 to 15 percent of the PAH contaminant burden and approximately 20 percent of the lead contaminant burden in the Lower Passaic River.

The Lower Passaic River is also a major source of contaminants to Newark Bay. Sediment transport from the Lower Passaic River to Newark Bay may be a significant source of the contaminants found in Newark Bay's surficial sediments, particularly 2,3,7,8-TCDD and mercury. It is estimated that the Lower Passaic River contributes approximately 10 percent of the average annual amount of sediment accumulating in Newark Bay, and more than 80 percent of the dioxin accumulating in the Bay. A recent study of dioxin contamination in New York Harbor (Chaky, 2003) provides a basis for tracing the Lower Passaic River dioxin signature through the entire Harbor. It is estimated that the Lower Passaic River also contributes approximately 20 percent of the mercury to Newark Bay. (Mass balances on the amount of PCBs, PAHs, pesticides, and metals entering Newark Bay from the Lower Passaic River were not performed.)

Sediment contamination is not the only problem in the Lower Passaic River. Because of development along the banks of the Lower Passaic, vital wetlands and floodplains have been eliminated so that many of the communities living on the banks of the river are prone to flooding. The impacts of potential remedial actions on flooding and wetland restoration have been considered. Further, the State of New Jersey's vision for future navigation infrastructure has been considered to help define the reasonably anticipated future use for the Passaic River (see Section B.5.2.2 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses").

A.1.5 On-Site and Surrounding Land Use

In general, the banks of the Lower Passaic River are highly developed with a combination of industrial, recreational, and residential land uses (see Section B.5.1.1 "Current On-Site Land Use" for further information). The Newark side of the river (*i.e.*, west and south bank) between RM0.0 and RM4.6 is fully industrially developed, and the Harrison side (*i.e.*, east and north bank) in this region is occupied by the railroad tracks of the Port Authority Trans Hudson (PATH) system and an intermodal container handling facility. Upriver of RM4.6, the west bank is dominated by McCarter Highway (New Jersey Route 21), which extends northward past Dundee Dam. The east and north bank in the area of RM4.6 is currently being redeveloped for a combination of residential and recreational uses. Continuing upriver to Dundee Dam, the east bank can be characterized as recreational parkland containing small public marinas and private docking facilities, with residential and light commercial areas also present. Current land use in the surrounding counties in New Jersey (*i.e.*, Bergen, Hudson, Essex, and Passaic Counties) consists of a combination of industrial, residential, and commercial uses.

A.1.6 Media and Primary Contaminants of Concern

The remedial alternatives developed in the FFS address contamination in the fine-grained sediments in the Area of Focus (lower eight miles). Contaminants of potential concern (COPCs) and contaminants of potential ecological concern (COPECs) as identified for the FFS [Malcolm Pirnie, Inc., 2008 (anticipated)] are listed in Table A.1-1.

Table A.1-1: COPCs and COPECs in the Sediments of the Lower Passaic River

Analyte	Human Health COPC	Ecological COPEC
Inorganic Compounds		
Copper		✓
Lead		✓
Mercury	✓	✓
Semivolatile Organic Compounds (PAHs)		
Low Molecular Weight (LMW) PAH [1]		✓
High Molecular Weight (HMW) PAH [2]		✓
PCBs		
Total PCBs (sum of Aroclors)	✓	✓
Pesticides/Herbicides		
Chlordane	✓	
Dieldrin	✓	✓
Dichlorodiphenyldichloroethane (DDD) [3]	✓	
Dichlorodiphenyldichloroethylene (DDE) [3]	✓	
Dichlorodiphenyltrichloroethane (DDT) [3]	✓	
Total DDT [3]		✓
Polychlorinated dibenzodioxins/furans (PCDD/F)		
2,3,7,8-TCDD	✓	✓
Tetrachlorodibenzodioxin (TCDD) Toxic Equivalent (TEQ) for PCDD/F	✓	✓
TCDD TEQ for PCBs	✓	✓

[1] LMW PAH is defined as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene. Samples flagged as not detected are incorporated into the summation as zero.

[2] HMW PAH is defined as the sum of benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, and pyrene. Samples flagged as not detected are incorporated into the summation as zero. Total PAH is the sum of HMW PAH and LMW PAH.

[3] DDD, DDE, and DDT refers only to the 4,4'-isomers. Total DDT is defined as the sum

of DDD, DDE, and DDT.

A.1.7 Operable Units and the Media Addressed by Each Operable Unit

The 17-mile stretch of the Lower Passaic River is an Operable Unit (OU) of the Diamond Alkali Superfund Site. The Source Control Early Action remedial alternatives address the Area of Focus, defined as the contaminated fine-grained sediments in the lower eight miles of the Passaic River, which is a portion of the OU.

A.2 RISK SUMMARY

Extremely contaminated surface sediments present risks to human health and the ecosystem that exceed the acceptable human health cancer risk range and noncancer hazard index and acceptable hazard quotients for ecological receptors identified in the National Contingency Plan (NCP; USEPA, 1990). A Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 ([anticipated)] conducted to support the FFS were performed consistent with the United States Environmental Protection Agency's (USEPA) risk assessment guidance, policies and guidelines (USEPA, 2001, 1998, 1997a, and 1989).

The focused HHRA concentrated on the ingestion of fish and crab as the primary exposure pathways, and evaluated risks from the bioaccumulative COPCs including PCBs, 2,3,7,8-TCDD, DDD, DDE, DDT, dieldrin, chlordane, and methyl mercury. The toxic equivalency factors (TEFs; Van den Berg *et al*., 1998 and Van den Berg *et al*., 2006) for dioxin and dioxin-like PCBs were used in the analysis. A full baseline HHRA for all chemicals, receptors, and exposure pathways will be conducted in the future for the entire 17-mile site to refine the conservative analyses conducted for the FFS.

Commented [FB1]: are they consistently conservative?

The HHRA concluded that risks to adults exposed for 24 years and children exposed for 6 years are 1×10^{-2} and 2×10^{-2}, respectively, for ingestion of fish and crab. The adults were assumed to consume 40 eight-ounce fish meals per year [25 grams per day from the Exposure Factors Handbook (EFH; USEPA, 1997b)], and the ingestion rate for children was adjusted based on body weight. The noncancer health hazards for fish consumption are 64 for adults and 99 for children; the noncancer health hazards for crab consumption are 86 for adults and 140 for children. A separate analysis for adolescents was also conducted. The associated cancer risks are 2×10^{-3} for ingestion of fish and 4×10^{-3} for ingestion of crab; the associated noncancer health hazards are 55 for ingestion of fish and 72 for ingestion of crab.

The risks from the reasonable maximum exposure (RME) and central tendency exposure (CTE) (described in Section 2.6.1 "Human Health Risk Assessment Summary") are greater than the acceptable risk range of one in ten thousand to one in a million established by the Superfund Program. Approximately 65 percent of the human health cancer risk is associated with the presence of dioxin. Most of the remaining cancer risk (approximately 33 percent) is from PCBs, while pesticides and mercury combined contribute approximately two percent. Total PCBs are the primary contributor to the excess noncancer hazard for all receptors for ingestion of both fish and crab. Accordingly, fish consumption advisories have been in place for many years due to contamination from dioxins and PCB.

The ERA [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] evaluated risks from direct contact and indirect exposure (*i.e.*, bioaccumulation through the food web) to contaminated sediment. Direct contact exposure risks were evaluated for receptors that live in or on the sediment. Indirect exposures associated with contaminant bioaccumulation were evaluated for aquatic organisms that forage in the Lower Passaic River and the wildlife that consume these organisms. Risks to receptors were calculated as hazard quotients (HQs) that compared exposure concentrations with concentrations known to cause adverse effects to those receptors. Receptors of interest included benthic macroinvertebrates, crab, fish (forage and predatory), mammals (mink), and birds (great blue heron).

A chemical screening process resulted in the selection of nine COPECs, including copper, lead, mercury, LMW PAH, HMW PAH, dieldrin, Total DDx (the sum of DDD, DDE and DDT concentrations), Total PCBs, and TCDD TEQ, including contributions from PCDD/F and PCB congeners. The ERA concluded that ecological receptors residing in the river are being adversely impacted by COPECs in sediment, invertebrate tissue and fish tissue. The individual COPECs presenting risk vary for each receptor group evaluated. The HQs estimated for the benthic macroinvertebrates range from 1.2 to 936 for COPECS in sediment and from 0.1 to 3,000 for bioaccumulated body burdens of COPECs. For the fish, HQs are between 0.00012 and 13,000 for body burdens of COPECs. HQs for mammals and birds range from 0.04 to 1,000 and 0.0002 to 45, respectively.

In general, a HQ above 1.0 is interpreted as indicating that risk, or the potential for adverse effects, is unacceptable; a HQ below 1.0 indicates that risk is negligible. The estimated risks to the ecological receptors (described in Section 2.6.2 "Ecological Risk Assessment Summary") are up to five orders of magnitude greater than 1.0. The COPECs contributing to risk vary with each of the receptors. In general, the primary COPECs for benthic invertebrates are pesticides (dieldrin and Total DDx) and TCDD TEQ for PCDD/F. For forage fish, copper is the risk driver, with some risk from Total PCBs. Copper and Total DDx contribute most substantially to risk (*i.e.*, are risk drivers) for predatory fish, with additional risk from PCBs. TCDD TEQs in the Passaic River present risk to piscivorous birds (represented by the great blue heron) with possible risk from exposure to mercury and total PCBs, while the TCDD TEQs, Total PCBs, copper and possibly mercury present risk to piscivorous mammals (represented by the mink). Total TCDD TEQs contributes to risk to both piscivorous birds and mammals; however, the relative contribution of PCDD/F and PCB compounds to the overall risk from TCDD TEQs differs substantially. For piscivorous mammals, represented by the mink, PCDD/F compounds accounted for 64% percent of the TCDD TEQ. The PCB compounds made the most substantial contribution to the TEQ for piscivorous birds.

A.3 REMEDIATION GOALS

Remedial Action Objectives (RAOs) were established to describe what the cleanup is expected to accomplish, and preliminary remediation goals (PRGs) were developed as targets for the cleanup to meet in order to protect human health and the environment.

The RAOs were developed by the USEPA with input from the partner agencies[1] regarding current and reasonably anticipated future uses of the site. The RAOs are as follows:

- Reduce cancer risks and noncancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of COPCs in fish and shellfish.

- Reduce the risks to ecological receptors by reducing the concentration of COPECs in fish, shellfish, benthic organisms and sediment.

- Reduce the mass of COPCs and COPECs in sediments that are or may become bioavailable.

- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a continuous source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

[1] The Lower Passaic River Restoration Project is being implemented by the USEPA under the Superfund Program; by the United States Army Corps of Engineers (USACE) and New Jersey Department of Transportation (NJDOT) under the Water Resources Development Act (WRDA); and by the United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and the New Jersey Department of Environmental Protection (NJDEP) as Natural Resource Trustees.

Applicable or relevant and appropriate requirements (ARARs), human health and ecological risk-based concentrations (RBCs), and background concentrations were evaluated in the selection of PRGs. The background concentrations derived from recent sediment data from above Dundee Dam were found to be above the risk-based thresholds. Since clean-up under the Superfund program generally does not target concentrations below natural or anthropogenic background levels (USEPA, 2002d), background concentrations in sediment above Dundee Dam were selected as PRGs. Table A.3-1 lists the background concentrations of COPECs and COPCs, selected as the PRGs.

Table A.3-1: Selected PRGs

Contaminant	Background Concentration (ng/g)
Copper	63,000
Lead	130,000
Mercury [1]	720
LMW PAH	7,900
HMW PAH	53,000
Total PCB	460
Sum of DDD, DDE, and DDT isomers (Total DDx)	30
Dieldrin	5
Chlordane	23
2,3,7,8-TCDD	0.0019

[1] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

The proposed remediation goals assume that institutional controls will be in place that will require that the current fish advisories in the Lower Passaic River be evaluated on an ongoing basis. It is anticipated that these advisories can be relaxed as contaminant concentrations continue to decline after implementation of the Source Control Early Action.

The COPC and COPEC concentrations known to exist in the surface sediments of the lower 8 miles are much greater than these PRGs. Furthermore, resuspended sediment in the lower 8 miles continues to be a source of contaminants to the Passaic River, allowing contaminant concentrations in biologically active surface sediment to remain high. For this reason a remedial strategy that can reduce contaminant concentrations in surface sediment to at least the level of background is necessary to begin to achieve the RAOs.

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action will need to be implemented above Dundee Dam to identify and reduce or eliminate those background sources.

The ultimate goal is to achieve sediment RBCs that allow the consumption of 40 fish meals per year without unacceptable risks to human health and eliminate risks to ecological receptors in and around the Passaic River. In the interim, the time to reach sediment RBCs for twelve fish meals, two fish meals, and one fish meal per year is considered. This interim goal would also result in a reduction in ecological risks. The time to reach these goals depends on the remedial alternative selected. Remedial alternatives are discussed in Section A.4. The time to reach PRGs and RBCs is discussed in Section B.7.

A.4 DESCRIPTION OF REMEDIAL ALTERNATIVES

A description of the No Action and nine active remedial alternatives for the Lower Passaic River Restoration Project is presented in Table A.4-1. The remedial alternatives and cost estimates were developed as part of the FFS [Malcolm Pirnie, Inc., 2008 (anticipated)].

The nine active remedial alternatives are equivalent in risk reduction and the estimated time to achieve preliminary remediation goals. Based on the prediction of future surface sediment concentrations generated in the Empirical Mass Balance (EMB) [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], active remediation of the Area of Focus followed by monitored natural recovery (MNR) will achieve all PRGs for 2,3,7,8-TCDD, which is responsible for about 65 percent of the current risk, approximately 40 years faster than it would be achieved by the No Action alternative. The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus.

Table A.4-1: Description of Active Remedial Alternatives

Alternatives	Navigation Usage and Navigation Channel Depths [(1)]	Dredging Volume (millions cy)	Construction Duration (years)	Human Health Risk Assessment [(2)] (Fish Consumption) [(3)]	Ecological Risk Assessment [(2)] (Heron) [(4)]	Total Present Worth Cost
Alternative 1 – No Action	Does not change existing navigation capacity; limits feasibility of future channel maintenance.	0	0	Cancer Risk: 4×10^{-3} (60 percent reduction compared to baseline) Noncancer HI: 44 for adult receptor; 68 for child receptor	Noncancer HI: 4.4	Minimal
Alternative 2 – Dredging with CDF Disposal	Authorized channel dimensions accommodated: • 30’ from RM0 to RM2.5 • 20’ from RM2.5 to RM4.6 • 16’ from RM4.6 to RM8.1 • 10’ above RM8.1	10.7	9.0	Cancer Risk: 6×10^{-4} (94 percent reduction compared to baseline) Noncancer HI: 11 for adult receptor; 17 for child receptor	Noncancer HI: 1.8	$1.4 Billion
Alternative 3 – Dredging with Off-Site Treatment and Disposal		10.7	8.5			$7.0 Billion
Alternative 4 – Dredging with Decontamination and Beneficial Use		10.7	8.5			$2.2 Billion
Alternative 5 – Capping with CDF Disposal	No navigation usage accommodated from RM0 to RM8.3. De-authorization of the navigation channel required in this area.	3.2	7.5			$0.93 Billion
Alternative 6 – Capping with Off-Site Treatment and Disposal		3.2	7.5			$2.5 Billion

Alternatives	Navigation Usage and Navigation Channel Depths [(1)]	Dredging Volume (millions cy)	Construction Duration (years)	Human Health Risk Assessment [(2)] (Fish Consumption) [(3)]	Ecological Risk Assessment [(2)] (Heron) [(4)]	Total Present Worth Cost
Alternative 7 – Capping with Decontamination and Beneficial Use		3.2	7.5			$1.1 Billion
Alternative 8 – Capping with Navigation and CDF Disposal	Anticipated future navigation usage accommodated: • 30' from RM0 to RM1.2 • 16' from RM1.2 to RM1.9 No navigation usage accommodated from RM1.9 to RM8.3. De-authorization of the navigation channel required in this area.	4.2	6.5			$0.99 Billion
Alternative 9 – Capping with Navigation and Off-Site Treatment and Disposal		4.2	6.5			$3.1 Billion
Alternative 10 – Capping with Navigation and Decontamination and Beneficial Use		4.2	6.5			$1.2 Billion

(1) Navigation channel depths are provided in feet below mean low water.
(2) Risk reductions are presented for a 30-year timeframe. Alternatives 2 through 10 rely on MNR with institutional controls in place to achieve human health cancer risk of $1x10^{-4}$ and noncancer HI = 1 in subsequent years. In addition, an Upper Passaic River and Dundee Dam source track down effort, if implemented, will accelerate the timeframe required to reach these thresholds. Quantitative estimates of risk reduction are subject to the uncertainties in the Empirical Mass Balance and Risk Assessment, as described in Section B.4.6. However, inferences inherent in these evaluations have been derived from a thorough and comprehensive understanding of the site through the Conceptual Site Model, which was built upon detailed geochemical data evaluations and the assimilation of various data sources.
(3) A HHRA was also conducted for the scenario of crab consumption. Refer to the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] for additional information.
(4) An ERA was also conducted for other species. Refer to the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] for additional information.

A.5 PREFERRED REMEDY

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A.6 STAKEHOLDER VIEWS

A.6.1 State's Position

State acceptance is not addressed in this document, but will be addressed in the Record of Decision (ROD). It is important to note that the NJDOT is the WRDA non-federal sponsor and the NJDEP is a Trustee for the site; both are agency partners participating in the Study. As such, input from the State of New Jersey was sought and considered throughout the development of the FFS. In addition, the NJDOT developed a memorandum outlining the State's recommendations for the depth of the navigation channel to accommodate future use; this memorandum guided the development of several remedial alternatives for the Lower Passaic River.

A.6.2 Major Stakeholders' Position

Community acceptance of the Source Control Early Action will be assessed in the ROD once public comments on the proposed plan have been reviewed and taken into account. Input from the public and interested stakeholders, including the partner agencies, was

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sought and considered throughout the development of the FFS. This occurred through various technical workgroup sessions organized and hosted by the USEPA, through publication of information on the project website (www.ourPassaic.org), publication of information to interested members of the public in the form of ListServ notices, and other community involvement activities.

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B. NRRB BRIEFING PACKAGE

B.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The Lower Passaic River Restoration Project ("the Study") is a comprehensive study of the 17-mile tidal portion of the Passaic River and its watershed in northern New Jersey. This integrated Study is being implemented by the USEPA under the Superfund Program (the Lower Passaic River is a part of the Diamond Alkali Superfund Site); by the United States Army Corps of Engineers (USACE) and NJDOT under WRDA; and by the USFWS, NOAA, and the NJDEP as Natural Resource Trustees. The scope of the Study is to gather data needed to make decisions on remediating contamination in the river to reduce human health and ecological risks, improve the water quality of the river, improve and create aquatic habitat, improve human use, and reduce contaminant loading in the Lower Passaic River, Newark Bay, and the New York-New Jersey Harbor Estuary.

The Study Area (118 square miles) is defined as the Lower Passaic River and its basin, which comprises the tidally-influenced portion of the river from the Dundee Dam (RM17) to Newark Bay (RM0), and the watershed of this river portion downstream of the dam, including tributaries such as the Saddle River, Second River, and Third River (Figure B.1-1).[2]

[2] Note that two systems exist for identifying locations in the Lower Passaic River (Figure 2.1-2). The system used in this document to identify locations along the river is based on the centerline of the USACE navigation channel. However, data evaluations for the Lower Passaic River use a slightly (about ¼ mile) different river mile system, which is referred to in this document as the "RI/FS system." The RI/FS system uses a centerline that is equidistant from each shore and independent of the federally authorized navigation channel. River mile locations in this document are provided using the USACE system, except where noted.

During the course of the Study, sediments in the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. An FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that major source. The Source Control Early Action will address contaminated sediments in the lower eight miles of the Passaic River (hereinafter referred to as the Area of Focus; Figure B.1-2), in order to more rapidly reduce risks to human health and the environment. The Source Control Early Action, which will be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is ongoing.

B.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Lower Passaic River has a long history of industrialization. During the 1800s, the areas surrounding the Lower Passaic River became a focal point for the industrial revolution in the United States. By the 20th century, Newark had established itself as the largest industrial-based city in the country. The urban and industrial development surrounding the Lower Passaic River, combined with associated population growth, have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Table B.2-1 contains a history of events surrounding the Diamond Alkali Superfund Site and creation of the Study. While this chronology of events is significant to the project, the Diamond Alkali site is not the only source of contamination in the Lower Passaic River. It is important to understand that sediment contamination in the Lower Passaic River, and other problems being addressed by the partner agencies, came from numerous parties and sources over the past 100 years or more, including direct discharges via spills, runoff, groundwater migration and outfall pipes, as well as indirect discharges through sewers. Population growth and development pressures have also contributed to the degradation of the Lower Passaic River.

TableB.2-1: Project History

Date	Activity
1940s	Manufacturing facility located at 80 Lister Avenue, Newark, New Jersey, begins producing DDT and phenoxy herbicides.
1951-69	Diamond Alkali Company (subsequently known as the Diamond Shamrock Chemicals Company) owns and operates a pesticides manufacturing facility at 80 Lister Avenue. In 1960, an explosion destroys several plant processes; also in 1960, production is limited to herbicides, including those used in the formulation of the defoliant “Agent Orange.” Diamond Alkali Company ceases operations in 1969.
1976	Congress authorizes the USACE to begin flood control study for the Passaic River Basin under WRDA.
1982	NJDEP releases fishing advisories for reduced consumption of white perch and white catfish in the Passaic River. River abutting 80 Lister Avenue closed for commercial fishing of American eel and striped bass.
1983	NJDEP and USEPA collect samples; high levels of dioxin detected in the Passaic River and at 80 Lister Avenue property.
1984	NJDEP issues Administrative Order of Consent (AOC) to Diamond Shamrock Chemicals Company to perform investigation of 80 Lister Avenue. NJDEP issues an AOC to Diamond Shamrock Chemicals Company to perform cleanup of select dioxin-contaminated properties and to perform investigation of 120 Lister Avenue.
1984	Diamond Alkali site listed on National Priority List.
1985	Investigation results released to public. Cleanup options for 80 and 120 Lister Avenue properties detailed in feasibility study.
1986	NJDEP presents cleanup options to public.
1987	USEPA and NJDEP hold public meeting to discuss the Proposed Plan for cleanup. USEPA selects interim cleanup plan (Record of Decision) for the 80 and 120 Lister Avenue portion of the Diamond Alkali Superfund Site, requiring the containment of contaminated materials.
1988	Diamond Alkali Superfund Site transferred from state lead under NJDEP to federal lead under USEPA.
1990	The federal court approves a Consent Decree among Occidental Chemical Corporation (OCC), as successor to Diamond Shamrock Chemicals Company, and Chemical Land Holdings, Inc. [now known as Tierra Solutions, Inc. (TSI)] and USEPA and NJDEP to implement the 1987 interim cleanup plan.
1994	USEPA and OCC sign an AOC to investigate the lower six-mile stretch of the Passaic River. Demolition of buildings at 80 Lister Avenue is completed.
1995	Field work begins on the lower six-mile stretch of the Passaic River.
1996-99	USEPA, at the request of the local community, explores the potential for implementing an alternative to the interim cleanup plan selected in 1987. Alternative plan not found. USEPA reviews and approves design of 1987 interim cleanup plan.

Date	Activity
1999	Congress authorizes the Hudson-Raritan Estuary Study, and the Passaic River is added as a priority site under WRDA "Section 312 Environmental Dredging."
2000	Congress authorizes the USACE to conduct the Lower Passaic River Ecosystem Restoration Study under WRDA. USACE initiates a Reconnaissance Study for the Lower Passaic River.
2000	USEPA interim cleanup begins at land portion of Diamond Alkali site, which included installation of a cap, slurry wall, and flood wall around the properties and groundwater pumping and treatment.
2001	Interim cleanup completed at land portion of Diamond Alkali site. USACE completes Reconnaissance Study for the Lower Passaic River.
2002	Urban Rivers Restoration Initiative launched; USEPA and USACE sign National Memorandum of Understanding for the purpose of coordinating the planning and execution of urban river cleanup and restoration.
2003	Six-mile study of Lower Passaic River expanded to include the extent of contamination in the lower 17 miles of the Passaic River. State and federal trustees sign a Memorandum of Agreement for Natural Resource Damage Assessment and Restoration for the Diamond Alkali Superfund Site and environs. USEPA, USACE, and NJDOT sign a Project Management Plan for the Lower Passaic River Restoration Project. Feasibility cost sharing agreement signed by USACE and NJDOT. Selection of Passaic River as one of eight national pilot projects of the Urban Rivers Restoration Initiative.
2004	USEPA enters into an AOC with 31 Potentially Responsible Parties (PRPs) to fund Superfund portion of the Lower Passaic River Restoration Project.
2004	USEPA and TSI sign an AOC to investigate Newark Bay. TSI was the sole PRP in this AOC.
2005	Twelve additional PRPs were added to the AOC for the Superfund portion of the Lower Passaic River Restoration Project.
2007	USEPA enters into a new AOC which turns the 17-mile Study over to the Cooperating Party Group (CPG), which consists of 73 members.

The legal history of the Lower Passaic River Restoration Project extends back to 1994, when USEPA and OCC signed an AOC to investigate dioxin in a six-mile stretch of the Lower Passaic River. At that time, OCC was the sole PRP, and dioxin was the sole COPC. The six-mile stretch was termed the Passaic River Study Area (PRSA). As a result of the sediment sampling conducted by TSI on behalf of OCC under this AOC, the USEPA decided to discontinue the six-mile study, while expanding the investigation to the entire 17 miles of the Lower Passaic River and a larger suite of chemicals. On June 22, 2004, the USEPA and 31 PRPs signed an AOC for the PRPs to fund USEPA's work on the 17-mile study area. In 2007, the PRP group [known as the Cooperating Parties Group (CPG)] was expanded to 73 (Table B.2-2), and the group took over the study of the 17-mile stretch with USEPA oversight.

Table B.2-2: Members of the Cooperating Parties Group

Number	Name of Cooperating Party
1	Alliance Chemical, Inc. on behalf of itself and Pfister Chemical, Inc.
2	Arkema, Inc.
3	Ashland, Inc.
4	Atlantic Richfield Company
5	BASF Corporation, on its own behalf and on behalf of BASF Catalysts, LLC
6	Belleville Industrial Center
7	Benjamin Moore & Co.
8	Bristol-Myers Squibb Company
9	CBS Corporation, a Delaware corporation, formerly known as (f/k/a) Viacom, Inc., successor by merger to CBS Corporation, a Pennsylvania corporation, f/k/a/ Westinghouse Electric Corporation
10	Celanese Ltd.
11	Chemtura Corporation and Raclaur, LLC as current and former owner or the property f/k/a Atlantic Industries
12	Chevron Environmental Management Company, for itself and on behalf of Texaco, Inc.
13	Coltec Industries
14	Conopco, Inc., doing business as Unilever (as successor to CPC/Bestfoods, former parent of the Penick Corporation (facility located at 540 New York Avenue, Lyndhurst, New Jersey)
15	Covanta Essex Company
16	Croda, Inc.
17	DiLorenzo Properties Company on behalf of itself and the Goldman/Goldman/DiLorenzo Properties Partnerships
18	E. I. du Pont de Nemours and Company
19	Eden Wood Corporation
20	Elan Chemical Company
21	EPEC Polymers, Inc. on behalf of itself and EPEC Oil Company Liquidating Trust
22	Essex Chemical Corporation
23	Flexon Industries Corp.

Number	Name of Cooperating Party
24	Franklin-Burlington Plastics, Inc.
25	Garfield Molding Co., Inc.
26	General Electric Company
27	General Motors Corporation
28	Givaudan Fragrances Corporation (Fragrances North America)
29	Goodrich Corporation of behalf of itself and Kalama Specialty Chemicals, Inc.
30	Hercules Chemical Company, Inc.
31	Hess Corporation, on its own behalf and on behalf of Atlantic Richfield Company
32	Hexcel Corporation
33	Hoffmann-La Roche, Inc. on its own behalf and on behalf of its affiliate Roche Diagnostics
34	Honeywell International, Inc.
35	ISP Chemicals, LLC
36	ITT Corporation
37	Kao Brands Company
38	Leemilt's Petroleum, Inc. (successor to Power Test of New Jersey, Inc.), on its behalf and on behalf of Power Test Realty Company Limited Partnership and Getty Properties Corp., the General Partner of Power Test Realty Company Limited Partnership
39	Lucent Technologies, Inc.
40	Mallinckrodt, Inc.
41	Millennium Chemicals, Inc. affiliated entities MHC, Inc. (on behalf of itself and Walter Kidde & Company, Inc.), Millennium Petrochemicals, Inc. (f/k/a Quantum Chemical Corporation) and Equistar Chemicals LP
42	National-Standard, LLC
43	Newell Rubbermaid, Inc., on behalf of itself and its wholly-owned subsidiaries Goody Products, Inc. and Berol Corporation (as successor by merger to Faber-Castell Corporation)
44	News Publishing Australia Ltd. (successor to Chris-Craft Industries)
45	Novelis Corporation (f/k/a Alcan Aluminum Corporation)
46	NPEC, Inc.
47	Occidental Chemical Corporation (as successor to Diamond Shamrock Chemicals Company)
48	Otis Elevator Company
49	Pfizer, Inc.
50	Pharmacia Corporation (f/k/a Monsanto Company)
51	PPG Industries, Inc.
52	Public Service Electric and Gas Company
53	Purdue Pharma Technologies, Inc.
54	Quality Carriers, Inc. as successor to Chemical Leaman Tank Lines, Inc., and its affiliates and parents

Number	Name of Cooperating Party
55	Reichhold, Inc.
56	Revere Smelting and Refining Corporation
57	Safety-Kleen Envirosystems Company by McKesson, and McKesson Corporation for itself
58	Sequa Corporation
59	Sun Chemical Corporation
60	Tate & Lyle Ingredients Americas, Inc. (f/k/a A. E. Staley Manufacturing Company, including its former division Staley Chemical Company)
61	Teva Pharmaceuticals USA, Inc. (f/k/a Biocraft Laboratories, Inc.)
62	Teval Corporation
63	Textron, Inc.
64	The BOC Group, Inc.
65	The Hartz Consumer Group, Inc., on behalf of The Hartz Mountain Corporation
66	The Newark Group
67	The Sherwin-Williams Company
68	The Stanley Works
69	Three County Volkswagen
70	Tiffany and Company
71	Vertellus Specialties, Inc. f/k/a Reilly Industries, Inc.
72	Vulcan Materials Company
73	Wyeth, on behalf of Shulton, Inc.

B.3 SCOPE AND ROLE OF RESPONSE ACTION

The 17-mile tidal portion of the Passaic River is an OU of the Diamond Alkali Superfund Site. Other OUs include the manufacturing facility located at 80-120 Lister Avenue in Newark, New Jersey, which has an interim remedy in place; and Newark Bay (including portions of the Hackensack River, Arthur Kill and Kill Van Kull), which is the subject of a separate, ongoing RI/FS.

As noted above, sediments in the lower eight miles of the river, a portion of the 17-mile Passaic River OU, have been identified as a major source of contamination to the 17-mile Study Area and to Newark Bay, and an FFS has been undertaken to evaluate a range of remedial alternatives for an early action to control that major source. The Source Control Early Action will address contaminated sediments in the lower eight miles of the Passaic

River (the Area of Focus) in order to more rapidly reduce risks to human health and the environment. Sediments in the Area of Focus consist of the predominantly fine-grained, contaminated sediment present in the Brackish and Transitional Sections[3] of the Lower Passaic River. Geomorphological data suggest fine-grained sediments exist in a contiguous stretch up to approximately RM8 and recent sediment probing and coring have identified non-congiguous areas of fine-grained sediments above RM8. While the preponderance of available contaminant data represents the area between RM1 and RM7, the Conceptual Site Model (CSM) [Malcolm Pirnie, Inc. 2008 (anticipated)] suggests that RM0 to RM1 and RM7 to RM8 will behave similarly to the area between RM1 and RM7. The Source Control Early Action, which will be a final remedial action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is on-going.

B.4 SITE CHARACTERISTICS

A comprehensive CSM[4] built upon detailed geochemical data evaluations and the assimilation of various data sources has been developed for the Lower Passaic River. The CSM for the Study was initially presented in the August 2005 version of the Work Plan (Malcolm Pirnie, Inc., 2005c). This CSM has been updated as part of the FFS [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. A summary of conclusions discussed in the CSM is presented below.

[3] As described in the CSM (Malcolm Pirnie, Inc., 2008a), the Lower Passaic River may be divided into three sections: a Freshwater section (RM10 to RM17.4) dominated by freshwater flow entering over Dundee Dam, a Brackish section (RM0 to RM6) dominated by saline waters from Newark Bay, and a Transitional section (RM6 to RM10) where the two mix.

[4] A CSM expresses a site-specific contamination problem through a series of diagrams, figures, and narrative consistent with USEPA Office of Solid Waste and Emergency Response (OSWER) remedial investigation and feasibility study guidance (USEPA, 1988).

The CSMs specific to the HHRA and ERA are described in Section B.6.1.1 “Risk Assessment Conceptual Site Model” and Section B.6.2.2 “Ecological Exposure Assessment,” respectively.

B.4.1 Site Overview

The Lower Passaic River is a partially stratified estuary where the degree of stratification and the location of the salt front at any point in time reflect a dynamic balance between the freshwater flow and the tidal exchange with Newark Bay. Tidal displacement in the Lower Passaic River is quite large, with the salt front moving several miles during each tidal cycle. The Lower Passaic River carries a large suspended solids load derived from upstream sources and Newark Bay, as well as mobilization of previously deposited solids due to tidal displacement.

The Lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around the Great Falls in Paterson, New Jersey. In subsequent years, a multitude of industrial operations developed along the banks of the Passaic River, as the cities of Newark and Paterson grew. These industrial operations included manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Moreover, the Lower Passaic River has been used as a major means of conveyance for municipal sewage and storm water discharges from the middle of the nineteenth century to the present time. Ultimately, many contaminants were discharged to the Lower Passaic River, including persistent contaminants such as PCDD/F, PAHs, PCBs, pesticides, and heavy metals.

An important component of the region’s development and urbanization was the deepening of the river to permit commercial vessels to travel to the city of Newark and farther upriver. Several large dredging projects were undertaken at the beginning of the twentieth century to create a navigation channel to approximately RM15. Since the 1940s, there has been little maintenance dredging above RM2. Consequently, extensive fine grained sediment deposits exist in the previously dredged channel, particularly between RM0 and RM8. The coincidence of contaminant discharges to the river and a significant suspended sediment load created an ideal situation for accumulating contaminated sediments. As a result, the river accumulated substantial sediment beds, measuring up to 25 feet thick in some areas. These thick sediment deposits remain, primarily below RM8 where the relatively wider river channel provided favorable conditions for rapid sediment accumulation.

Much less accumulation has occurred upstream of RM8 because of the narrower channel. The change in river geometry is illustrated in Figure B.4-1, which shows the relationship between location and the river's cross sectional area. The larger cross-sectional area is due primarily to the width of the river, with a larger cross-sectional area also implying a slower flow velocity.

Despite the prevalence of thick sediment deposits below RM8, the sediments in this region are not all stable, and erosional areas have been identified throughout the lower 8 miles of the river. These erosional areas provide continuing releases of contaminant-bearing solids from the legacy sediments on the river bed. This is shown in Figure B.4-2, which plots the fractions of depositional and erosional areas as a function of location (river mile), calculated for quarter-mile increments. A detailed examination of sediment deposition rates between RM1 and RM7 indicates a high degree of spatial heterogeneity, with local rates varying from about 6 inches/year of net erosion to about 8 inches/year of net deposition. Historical deposition rates were probably higher than current rates (and erosional areas fewer and smaller) because of the more extensive salt front intrusion and deeper channel depths immediately after the initial channel dredging, which would have enhanced settling of suspended sediment.

A comparison of current and historical mass balances of solids coming into the Lower Passaic River shows that the relative importance of the solids load coming from the head-of-tide has increased over the years, compared to that coming from Newark Bay. The current head-of-tide solids load to the Lower Passaic River is greater than the annual average rate of accumulation in the river; however, the historical rates of sediment accumulation in the Lower Passaic River were probably too large to be sustained solely by the Passaic's head-of-tide solids loads, suggesting that solids transport from Newark Bay were likely to have supplied the additional solids.

B.4.2 Site Geology

The Lower Passaic River is situated within the Newark Basin portion of the Piedmont physiographic province, located between the Atlantic Coastal Plain Province and the Appalachian Plateau (Fenneman, 1938). The Newark Basin is underlain primarily by sedimentary rocks (sandstone, shale, calcareous shale, and conglomerate), to a lesser extent by igneous rocks (basalt and diabase), and may locally be underlain by metamorphic rocks (slate and schist). The Newark Basin rocks are from the mid-Triassic to early Jurassic periods. Bedrock underlying the Lower Passaic River is the Passaic Formation (Olsen *et al.*, 1984; Nichols, 1968), consisting of interbedded red-brown sandstone and shale.

Almost the entire Passaic River Basin, including the Lower Passaic River, was subjected to glacial erosion and deposition as a result of the last Wisconsin glaciation stage. Considerable quantities of stratified sand, silt, gravel, and clay were deposited throughout the area. These glaciofluvial deposits, in the form of glacial lake sediments, overlie bedrock and underlie the Meadowlands section of Newark Basin.

Sediment sampling programs conducted in the Lower Passaic River have typically encountered deposits of silt overlying sequences of sand and, in some cases, red-brown clay. The thickness of the silt deposit in a given location has been shown to correlate well with the depth of the constructed navigation channel at that location, suggesting that the navigation channel was constructed by dredging into the sand sequence.

B.4.3 Surface Water Hydrology

The Lower Passaic River and the Hudson-Raritan Estuary are a unique hydrologic system that encompasses a major metropolitan area in the United States, including two major cities: New York City, New York and Newark, New Jersey. Since the American industrial revolution, this area has experienced significant urbanization and industrial development, which has consequently impacted the surrounding ecosystems and waterways. Discharges of industrial waste and municipal sewage have degraded sediment and water quality in the estuary. As contaminated solids and water enter the system, they are diluted and are disseminated throughout the estuary by the incoming and outgoing tides. These tides cause twice-daily mixing of surficial sediments through the resuspension and redeposition of solids. Over time, solids that originated from one end of the estuary (*e.g.*, the Lower Passaic River) are transported to other regions of the estuary (*e.g.*, the Hudson River).

Dundee Dam (located at RM17.4) divides the Upper Passaic River from the Lower Passaic River (Figure B.1-1). The Upper Passaic River meanders across several geologic settings, draining urban, suburban, and rural portions of northeastern New Jersey. The Upper Passaic River watershed includes 16 Superfund sites and 2,216 New Jersey Known Contaminated Sites. Soils and groundwater at these sites are contaminated with an array of chemicals.

The Lower Passaic River is divided into three river sections, as noted above in Section B.3 “Scope and Role of Response Action”, and is bounded by the Dundee Dam and Newark Bay (Figure B.4-3). In general, freshwater and solids flow over the Dundee Dam, enter the Freshwater River Section, and flow downriver to Newark Bay. Freshwater from the Lower Passaic River flows downriver over the salt wedge to Newark Bay. Saline water from Newark Bay moves upriver beneath the freshwater flow. The mixing of fresh and saline waters creates the Brackish and Transitional River Sections. Solids originating above the dam, solids eroding along the length of the lower river, solids transported upriver from Newark Bay, and those solids discharged from other sites (including combined sewer overflows (CSOs) and tributaries) are continuously mixed by tidal action, resuspending and redepositing surface sediment. These processes cause the continuous re-working of fine-grained sediments on the surface of the river bed.

Dated sediment cores that document the magnitude of the historical contaminant concentration to the Lower Passaic River record similar concentration histories, despite the distance separating the cores. This observation is direct evidence of the effectiveness of tidal mixing in the Lower Passaic River, where sediments are well homogenized prior to deposition. Moreover, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history and is not controlled by proximity to source. Thus, thick sequences of contaminated sediments will tend to have similar inventories of contaminants throughout the Brackish River Section and even into the Transitional River Section of the river.

B.4.4 Sediment Characteristics

B.4.4.1.1 Data Sources Used to Characterize Sediments

Numerous data sources were considered and utilized in the various data analysis and modeling efforts on which the analysis of the remedial alternatives was based. Table B.4-1 summarizes the data sets presented in the CSM [Malcolm Pirnie, Inc. 2008 (anticipated)] that were used to develop a thorough understanding of site characteristics and site processes. These data sets were supplemented with literature data that are referenced in the CSM.

Table B.4-1: Data Sets Presented in the CSM [Malcolm Pirnie, Inc. 2008 (anticipated)]

Study Name (1)	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	3 (2)	Above Dundee Dam	Sediment Grab
1991 Core Sediment Investigation	1991	1 (2)	Above Dundee Dam	Sediment Core
1995 Remedial Investigation Sampling Program	1995	97	RM0.9 to RM6.8	Sediment Core (4)

Study Name (1)	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1999 Sediment Sampling Program	1999	1 (5)	RM6.2	Sediment Core (3)
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core (3)
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab
Newark Bay 2005 Remedial Investigation Work Plan Phase 1 Dataset	2005	69	Newark Bay	Sediment Core (3)
2005-2006 USEPA Sampling Program High Resolution Cores	2005	5	RM1.4 to RM12.6	Sediment Core (4)
2007-2008 USEPA Sampling Program Surface Sediment	2007-2008	RM1.4 to RM14.6: 24. Above Dundee Dam: 4	RM1.4 to RM14.6, Above Dundee Dam	Sediment Grab
2007-2008 USEPA Sampling Program Tributaries	2007-2008	4	Tributaries	Suspended Solids
2007-2008 USEPA Sampling Program CSOs/SWOs	2007-2008	5 CSOs, 8 SWOs	CSO: RM5 to RM8 SWOs: RM3 to RM11	Suspended Solids

(1) Data are available at www.ourPassaic.org.
(2) Only sample locations above the Dundee Dam were evaluated.
(3) Only surface sediment samples are presented in the CSM.
(4) All data from sediment core were evaluated to develop the CSM.
(5) Only one sampling location was incorporated into CSM since the other samples were mis-projected.

Table B.4-2 provides an additional list of the historical datasets evaluated in the Comprehensive CSM and in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c).

Table B.4-2: Historical Data Sets Referenced in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c) and Comprehensive CSM

Commented [FB7]: Shouldn't we just list those that are "additional" and not re-iterate the entire suite?

Study Name (1)	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	2 (2)	RM3.2 to RM7	Sediment Grab
1991 Core Sediment Investigation	1991	14 (2)	RM0.2 to 7	Sediment Core (3)

Study Name [1]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
2004 Newark Bay Remedial Investigation Work Plan	1991-1998	32	Newark Bay	Sediment Core [4]
1992 Core Sediment Investigation	1992	4 [2]	RM1.1 to RM7	Sediment Core [4]
1993 Core Sediment Investigation – Part 1 (March 1993)	1993	8 [2]	RM0.3 to RM7	Sediment Core [3]
1993 Core Sediment Investigation – Part 2 (July 1993)	1993	11	RM0.5 to RM3	Sediment Core [3]
1994 Surficial Sediment Investigation	1994	18 [2]	RM3.5 to RM7.8	Sediment Grab
1995 Remedial Investigation Sampling Program	1995	97	RM1 to RM6.8	Sediment Core [3]
1995 Sediment Grab Sampling Program	1995	7	RM2.4 to RM2.7	Sediment Grab
1995 USACE Minish Park Investigation	1995	10	RM3.7 to RM5.5	Sediment Core [3]
1996 Newark Bay Reach A Sediment Sampling Program	1996	4	Newark Bay	Sediment Core [4]
1998 Newark Bay Elizabeth Channel Sampling Program	1998	3	Newark Bay	Sediment Grab and Sediment Core [4]
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999 Newark Bay Reach ABCD Baseline Sampling Program	1999	10	Newark Bay	Sediment Grab
1999 Sediment Sampling Program	1999	1 [5]	RM6.2	Sediment Core [4]
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core [4]
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab

[1] Data are available at www.ourPassaic.org.
[2] Only sampling locations between RM0 and RM7 were evaluated.
[3] All data from the sediment core were evaluated in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c).
[4] Only surface sediment samples were evaluated in the Draft Geochemical Evaluation (Step 2).
[5] Only one sampling location was incorporated into Draft Geochemical Evaluation (Step 2) since the other samples were mis-projected.

The specific, refined sampling efforts that were used in the Comprehensive CSM [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] to quantify the contribution of the various sources of contamination to the Lower Passaic River are discussed in Section B.4.6.1 "Empirical Mass Balance."

In addition to the data sets presented above, it is important to note that numerous non-chemical data sets (*e.g.*, bathymetry data, data obtained from geotechnical sediment cores, sediment texture data) have been critical in refining the understanding of site processes.

High resolution sediment cores (or “dated sediment cores”; listed in Table B.4-1 and Table B.4-7) and the surface sediment samples collected in 2007-2008 have played an integral role in the geochemical evaluations and mass balance modeling efforts to date. Data from the high resolution cores and the surface sediment have proven to be a powerful tool and have been used extensively. High resolution sediment cores document the history of contaminant inputs, transport, and transformation. Differences among contaminant histories in high resolution sediment core records can document the introduction and approximate location of contaminant sources. High resolution sediment cores can document the degree to which contaminated sediments are mobilized in the river during extreme flows; this is critical in evaluating remedial alternatives. Additionally, contaminant histories and associations derived from high resolution sediment cores can provide a basis to limit future analytical costs (Malcolm Pirnie, Inc., 2005c).

To summarize their importance, high resolution sediment cores can help to:

- Understand contaminant distribution in the Lower Passaic River as a function of distance along the river.

- Understand the long-term fate of contaminants within the sediments, such as long-term transformation processes.

- Document the effects of past events, such as the impacts of major storm events, on sediment beds (as an empirical indicator of sediment stability during extreme events) and the introduction of contaminants to the river.

- Provide data on time-dependent functions (*e.g.*, mixing and source inputs).

- Augment the calculation of contaminant mass and sediment volumes based on finer sampling intervals and more accurate estimation of sedimentation rates than can be achieved by low resolution sediment cores and bathymetric surveys alone, since these cannot provide a complete historical picture of the contaminant inputs or accumulation.

- Provide additional data to understand the complex interactions of contaminants, sediments, time, river flow and tide, and adjacent water bodies.

- Provide information on current sources and loads as context for assessing the effectiveness of remedial alternatives, including providing a basis to evaluate the potential for recontamination from adjacent water bodies.

The surface sediment samples collected in 2007-2008 are considered to represent recently deposited sediment. Recently deposited sediments are a distinct subset of the surface sediments that reflect the chemical characteristics of suspended sediments as they settle out of the water column at the time of their collection. Recently deposited sediments used in sediment characterization include: 2007-2008 Beryllium-7 (Be-7) bearing sediments collected in the Lower Passaic, tributaries and Upper Passaic River, and the 2005-2007 high resolution core tops in the Lower Passaic and Upper Passaic River. The list of COPCs and COPECs in the sediments of the Lower Passaic River was developed for the Risk Assessment [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and is summarized in Table B.4-3.

Types and characteristics of COPCs and COPECs (*e.g.*, toxic, carcinogenic, non-carcinogenic) are discussed Section B.6.1.2 “Types and Characteristics of Contaminants of Potential Concern.”

Table B.4-3: COPCs and COPECs in the Sediments of the Lower Passaic River

Analyte	Human Health COPC	Ecological COPEC
Inorganic Compounds		
Copper		✓
Lead		✓
Mercury	✓	✓
Semivolatile Organic Compounds (PAHs)		
LMW PAH [1]		✓
HMW PAH [2]		✓
PCBs		
Total PCBs (sum of Aroclors)	✓	✓
Pesticides/Herbicides		
Chlordane	✓	
Dieldrin	✓	✓
DDD [3]	✓	
DDE [3]	✓	
DDT [3]	✓	
Total DDT [3]		✓
PCDD/F		
2,3,7,8-TCDD	✓	✓
TCDD TEQ for PCDD/F	✓	✓
TCDD TEQ for PCBs	✓	✓

[1] LMW PAH is defined as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene. Samples flagged as not detected are incorporated into the summation as zero.

[2] HMW PAH is defined as the sum of benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, and pyrene. Samples flagged as not detected are incorporated into the summation as zero. Total PAH is the sum of HMW PAH and LMW PAH.

[3] DDD, DDE, and DDT refers only to the 4,4'-isomers. Total DDT is defined as the sum of DDD, DDE, and DDT.

B.4.4.2 Nature and Extent of Sediment Contamination

One important observation from the lateral and vertical extent of chemical contamination in the Lower Passaic River is the extent of tidal mixing throughout the river. Concurrently-deposited sediments throughout the Lower Passaic River have very similar concentrations of contaminants, indicating that sediments are well-homogenized prior to deposition. Thus, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history at that location and is generally not controlled by proximity to source. As a result, thick sequences of contaminated sediments will tend to have similar inventories of contaminants regardless of their location in the river, as illustrated by Lower Passaic River dated sediment core profiles for 2,3,7,8-TCDD (Figure B.4-4) and Total PCBs (Figure B.4-5). Note that these figures are just two examples of 31 figures presented in the EMB (Appendix A of the FFS; Malcolm Pirnie, Inc., 2008).

Contaminant inventories (*i.e.*, mass, not concentration) are not evenly distributed and vary along the length of the Lower Passaic River, with maximum values occurring near the areas encompassing RM1 to RM2, RM3 to RM4, and RM6 to RM7 (Figure B.4-6). The coring data that form the basis for these inventories show a high degree of local spatial heterogeneity, indicating that discrete areas of relatively higher concentrations typically described as “hot spots” likely do not exist. Instead, the data indicate the presence of “hot zones” of the river on the scale of a mile or more, nearly bank to bank (*i.e.*, the width of the navigation channel plus historical berth areas) in lateral extent. This conclusion does not, however, diminish the significance of potential historic or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. If very localized gradients in the sediment need to be identified, it is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) might be necessary.

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The legacy of sediment contamination in the Lower Passaic River likely extends back at least to the mid-nineteenth century, as illustrated by the vertical extent of contamination in the sediments. The oldest contaminants found in the sediments are PAH compounds, cadmium, mercury, and lead, which probably pre-date the turn of the twentieth century. Following these contaminants are, in order of chronological appearance in the river, DDT; 2,3,7,8-TCDD; and PCB. Other contaminants, such as arsenic, chromium, and copper are also present in the sediment record. The vertical extent of these contaminants is illustrated schematically in Figure B.4-7. Details of the geochronology of these chemical classes and the patterns in surface sediment concentration are further described below.

History of Sediment Contamination: Summary of Sediment Geochronological Analysis

Dated sediment cores for the Lower Passaic River (RM1 to RM7) from the 1995 TSI data set show that the major releases of 2,3,7,8-TCDD began in the late 1940s to early 1950s and peaked in the late 1950s to early 1960s. The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace Lower Passaic River PCDD throughout the Newark Bay complex and over the last 60 years. Based on dated sediment cores, this diagnostic ratio is observed throughout the sediments of the Lower Passaic River as far back as the 1950s. Prior to 1950, however, the 2,3,7,8-TCDD/Total TCDD ratio declines to a value of 0.1, approaching the value of 0.06, which is characteristic of sewage and atmospheric fallout (Chaky, 2003). The 2006 low resolution sediment cores indicated that 2,3,7,8-TCDD is not detected in the sand layer underlying the fine-grained sediment beds.

Dated sediment cores reveal that Total DDT discharges to the Lower Passaic River began in the 1930s and peaked in the late 1940s or early 1950s, consistent with the observations of Bopp *et al.* (1991a). Results consistently show measurable Total DDT concentrations occurring deeper in a sediment core than measurable 2,3,7,8-TCDD concentrations.

Total PCB contamination is distributed throughout the Lower Passaic River with peak concentrations [4 to 18 milligrams per kilogram (mg/kg)] occurring in the sediments dating to the 1960s or later. Hence, the extent of Total PCB contamination in the sediment beds is shallow when compared to mercury, lead, 2,3,7,8-TCDD, and Total DDT. Aroclor 1248 is the most commonly reported PCB mixture, typically comprising 60 percent or more of the Total PCB concentration.

Total PAH contamination is unique in its temporal distribution, with the highest concentrations observed in the deepest core layers, gradually declining to the most recent deposition. The presence of Total PAH contamination in the sand layer underneath the thick silt deposits may represent historical deposition or, alternatively, a contaminated groundwater source. Ratio analysis of Total PAH shows that the majority of PAH contamination in the sediments is derived from combustion-related processes (Malcolm Pirnie, Inc., 2006c), including coal tar residue (a by-product of manufactured gas plant processes) and urban background combustion. Of these combustion-related processes, coal tar wastes are historically the dominant source to the Lower Passaic River based on the prevalence of coal tar-like PAH ratios in more-contaminated sediments. The same analysis essentially rules out creosote-derived contamination and suggests that only minor portions of the sediment PAH contamination are derived from a petrogenic source (*e.g.*, oil spills).

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Dated sediment cores from the TSI 1995 data set indicate that major contamination of heavy metals likely occurred in the 1930s or earlier. Elevated concentrations of arsenic (approximately 60 mg/kg), chromium (approximately 800 mg/kg), copper (approximately 700 mg/kg), and lead (approximately 700 mg/kg) occur at depth in dated sediment cores, usually reaching their maxima at core bottoms. This evidence indicates that the vertical extent of these contaminants is undefined and that, potentially, major inventories of these contaminants lie below the documented depth of 2,3,7,8-TCDD contamination. Dated sediment cores were also unable to establish the depth of contamination for mercury and cadmium; however, the analysis of 2006 low resolution sediment cores indicated that the sand layer underneath the fine-grained sediment beds was contaminated with mercury as well as other metals. The presence of mercury and the other contaminants at this depth suggests that they may have been present in the Lower Passaic River since the time of the original construction of the navigational channel.

Sediment Concentrations

Patterns and trends in surface sediment concentrations based on the 1995 TSI data set were presented in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). For the 1995 data set, most of the contaminants examined have no trend, yielding no evidence to suggest multiple sources within the Lower Passaic River. The concentrations of three metals (arsenic, chromium, and mercury) statistically increased in the downriver direction, suggesting the possibility of two sources, one at each end of the Lower Passaic River (*i.e.*, a possible second source downriver of the original source may be contributing to the observed downriver increase in metal concentrations). Meanwhile, lead and PAH had a statistically decreasing trend downriver, suggesting that their primary source exists upriver of RM7. However, while trends were identified in these data sets, low regression coefficients and high variability only weakly support the presence of a second source with typical concentration changes of 50 percent or less. For most contaminants, tidal mixing is sufficient to homogenize the impacts of local loads, resulting in no significant gradients in the Lower Passaic River.

The EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] used a specific set of contaminants (including contaminants other than COPCs and COPECs as appropriate) to further characterize the Study Area. The average surface sediment concentrations of select contaminants (as presented in the EMB) in recently deposited sediments are presented in Table B.4-4. [Note that a separate set of average surface sediment concentrations were calculated as part of the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]; these data are not presented here.]

The data in Table B.4-4 are derived from analysis of the top segments of five high-resolution sediment cores collected at various locations in the river. Recently-deposited surface sediments in the Lower Passaic River are defined as those deposited during the 2003-2005 time period. Table B.4-4 also presents length-weighted average (LWA) concentrations of select contaminants in the Lower Passaic River using down-core data from the same five sediment cores. LWA concentrations represent a method of describing concentrations potentially available for resuspension. LWA concentrations integrate the entire thickness of contaminated sediments into one value for each contaminant, equivalent to the river eroding and resuspending sediment from all possible historical sediment layers on a roughly equal basis. [The EMB [included in the CSM, Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] provides more detail on the calculation of average surface sediment concentrations and LWA concentrations.]

Table B.4-4: Lower Passaic River Average Surface Sediment Concentrations and LWA Concentrations for Select Contaminants [modified from Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Analyte	Average Surface Sediment Concentration (RM1.4, RM2.2, RM7.8, RM11, and RM12.6) (1)	LWA Concentration
Mercury (mg/kg)	1.8	5.7
Lead (mg/kg)	210	420
Cadmium (mg/kg)	3.6	11
Trans-Chlordane (µg/kg)	33	44
DDE (µg/kg)	54	200
2,3,7,8-TCDD (ng/kg)	280 (2)	3,600 (2)
Total TCDD (ng/kg)	420 (2)	4,100 (2)
BZ (3) 31 (µg/kg)	26	270 (2)
BZ 52 (µg/kg)	35	270 (2)
BZ 61+66+70+74+76 (µg/kg)	85	640 (2)
BZ 83+99 (µg/kg)	21	110 (2)
BZ 90+101+113 (µg/kg)	34	180 (2)
BZ 93+95+98+100+102 (µg/kg)	28	150 (2)
BZ 110+111+115 (µg/kg)	35	190 (2)
BZ 129+138+158+160+163+164 (µg/kg)	45	170 (2)
BZ 139+140+147+149 (µg/kg)	34	130 (2)
BZ 170 (µg/kg)	11	33 (2)
BZ 180+193 (µg/kg)	27	80 (2)
Benz[a]anthracene (mg/kg)	3.1	3.7
Benzo[a]pyrene (mg/kg)	3.6	3.7
Chrysene (mg/kg)	4.3	5.1
Fluoranthene (mg/kg)	6.5	8.2
Indeno[1,2,3-cd]pyrene (mg/kg)	2.9	2.6
Pyrene (mg/kg)	6.1	7.9

µg/kg – microgram per kilogram
ng/kg – nanogram per kilogram
(1) RI/FS river mile system is used.
(2) Average concentration for only three river locations (RM1.4, RM2.2, and RM11). RI/FS river mile system is used.
(3) BZ is the Ballschmiter and Zell (1980) system for PCB congener nomenclature in which congeners are arranged in ascending numerical order based on the number of chlorine atoms and their substitution pattern on the biphenyl base structure. The BZ system of PCB shorthand notation was subsequently recognized by the International Union of Pure and Applied Chemistry and is the generally accepted notation used by scientists who perform congener-specific PCB research.
Concentrations rounded to two significant figures, whenever possible.

B.4.4.3 Sources of Sediment and Contamination

An empirical mass balance approach (see Section B.4.6.1 "Empirical Mass Balance Model") was used to understand the relative importance of the sources of sediment and associated contamination to the Lower Passaic River. Surface sediments that accumulate in the Lower Passaic River are comprised of solids that originated from the Upper Passaic River (located above the Dundee Dam), Newark Bay, major tributaries (including the Saddle River, Second River, and Third River), CSOs and stormwater outfalls (SWOs), and river-bottom sediment resuspension (Figure B.4-8). In general, external contaminant sources (by themselves) cannot account for the observed COPC concentrations in Lower Passaic River surface sediments, indicating that an internal source, or more specifically, resuspension of legacy sediments, is contributing to the contaminant burden of recently deposited surface sediments in the river [Appendix D of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. As a fraction of the total solids flux to the Lower Passaic River, resuspension of legacy sediments (*i.e.*, the historical inventory; referred to as Lower Passaic River Integrated Sediment) comprises about 10 percent of the total annual deposition. The relative contributions from the Upper Passaic River and Newark Bay are roughly equal with respect to solids, comprising approximately 40 percent each. In terms of the contaminant loads, however, the Upper Passaic River is clearly the more important of the two (see below). Tributaries and CSO/SWOs account for the remaining 10 percent of solids contribution to the Lower Passaic River.

As part of the EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], ratio analysis of several organic constituents has permitted the "fingerprinting" of the source material. Using these techniques, 2,3,7,8-TCDD contamination is shown to be derived almost exclusively from resuspension of legacy sediments (which were contaminated by historical industrial discharges) in the Lower Passaic River (Figure B.4-9). Results of the EMB indicate that the Upper Passaic River is the dominant source of PAH compounds to the Lower Passaic River, accounting for at least 50 percent of the contaminant load and often much more [as illustrated by benzo[a]pyrene and fluoranthene (both HMW PAH compounds); Figure B.4-10 and Figure B.4-11]. PAH patterns indicate that the majority of PAH contamination in the sediments is derived from combustion-related processes, particularly coal tar waste. For PCB, there are two main sources to the Lower Passaic River of roughly equal magnitude. The resuspension of legacy sediments contributes a mixture of LMW PCB congeners (as illustrated by BZ 52; Figure B.4-12) while the flow from the Upper Passaic River contributes a higher molecular weight PCB mixture (as illustrated by BZ 180+193; Figure B.4-13). The combination of the resuspension of legacy sediments and the flow from the Upper Passaic River account for nearly 75 percent (approximately 50 percent from resuspension and approximately 25 percent from Upper Passaic River flow) of the DDE contaminant burden to the river (Figure B.4-14). Sources of mercury contamination to the Lower Passaic River are similar to those for DDE (Figure B.4-15). The mass balance for lead indicates roughly equal contaminant contributions from five sources (resuspension of legacy sediments, flow from the Upper Passaic River, flow from Newark Bay, flow from major tributaries, and CSO/SWO discharges), approximately 20 percent each (Figure B.4-16).

The CSM demonstrates that toxic constituent concentrations in the water column (*i.e.*, dissolved concentrations) and in biota (*i.e.*, tissue concentrations) of the Lower Passaic River are largely driven by solids-bound contamination (*i.e.*, associated with sediments and resuspended solids), particularly for 2,3,7,8-TCDD [Malcolm Pirnie, Inc. 2008 (anticipated)]. While ongoing external inputs exist, solids-bound concentrations are responsible for much of the dissolved contamination within the water column.

B.4.4.4 Estimated Volume of Contaminated Sediment and Associated Mass of Contaminants

The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cy (USEPA, 2002c) and Fox River PCB site at 8 million cy (USEPA, 2003b)], but these inventories are spread over much greater distances than the eight miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cy for RM0.9 to RM7, with an average depth of contamination ranging from 7 to 13 feet. The evidence from sidescan sonar and bathymetric surveys suggests that the conditions observed in RM0.9 to RM7 probably also apply over the area of RM0 to RM8, suggesting that the actual inventory of contaminated sediments is at least one-third greater than the values obtained in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). Extrapolation of the estimated contaminant sediment volume into RM0 to RM1 and RM7 to RM8 results in an estimate of 6 to 10 million cy of contaminated sediment in RM0 to RM8.

The volume of 2,3,7,8-TCDD-contaminated sediments is somewhat smaller than the overall contaminated sediment volume, since several contaminants are present at greater depths than 2,3,7,8-TCDD. The estimate of 2,3,7,8-TCDD-contaminated sediment volume ranges from 5 to 6.5 million cy for RM0.9 to RM7.

The mass of contaminants contained within the sediments is also quite large (Table B.4-5). Moreover, the mass of 2,3,7,8-TCDD represents one of the largest site inventories in the United States.

Table B.4-5: Summary of Contaminant Inventory Estimates for RM0.9 to RM7

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Inventory Estimate [1]	Total DDT (metric tons)	2,3,7,8-TCDD (metric tons)	Mercury (metric tons)	Total PCB (metric tons)
Based on measured core intervals only	6.4	0.020	24	6
Based on measured and extrapolated core profiles	11	0.029	37	8
Percent Increase [2]	72 percent	45 percent	54 percent	33 percent

[1] Based on information provided in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c).

[2] Percent increase is relative to the extrapolated mass estimate (*i.e.*, the second row of the table).

B.4.4.5 RCRA Hazardous Wastes and Affected Media

On-site remedial actions conducted under the CERCLA must comply with (or receive a waiver for) requirements of the Resource Conservation and Recovery Act (RCRA) that are determined to be ARARs. The USEPA has determined that sediments from the Lower Passaic River do not contain a listed hazardous waste. Thus, a data analysis was performed as part of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] to determine whether sediment from the Lower Passaic River could be classified as a characteristic waste due to toxicity as defined through the Toxicity Characteristic Leaching Procedure (TCLP).

TCLP data are not available for Lower Passaic River sediments. However, in lieu of the TCLP extraction, Section 1.2 of the TCLP procedure (USEPA Method 1311; USEPA, 1992) allows for a total constituent analysis which may be divided by 20 to convert total results into the maximum hypothetical leachable concentration. This factor is derived from the 20:1 liquid-to-solid ratio employed in the TCLP method. Additional information on the use of the total constituent analysis in lieu of the TCLP method is described in the USEPA's "Monthly Hotline Report: Hotline Questions and Answers" (1994). The total constituent analysis was performed on maximum sediment concentrations from Lower Passaic River sediment cores collected in 1991, 1993, and 1995. Appendix H of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] contains further detail on the methodology and the results of this analysis. The results are summarized in Table B.4-6.

Table B.4-6: Percentage of Sediment Samples that Could Exceed Toxicity Characteristic Thresholds for Various Analytes

Contaminant	Exceedance Percentage	TCLP Threshold (mg/L)
1,4-Dichlorobenzene	2.5	7.5
2,4,6-Trichlorophenol	0.14	2
2,4-D	0.18	10
2,4-Dinitrotoluene	0.14	0.13
Arsenic	1.5	5
Cadmium	13	1
Chlordane	0.14	0.03
Chromium	73	5
Endrin	0.28	0.02
Hexachlorobenzene	0.66	0.13
Lead	83	5
Mercury	53	0.2
Selenium	0.15	1

mg/L = milligrams per liter

The analysis concluded that there is a reasonable probability that some sediment from the Lower Passaic River could exceed toxicity characteristic criteria if the TCLP test were performed; this likelihood has been accounted for in development of scenarios for dredged material management (DMM). In particular, based on this analysis, the analytes most likely to exceed the toxicity characteristic thresholds are chromium, lead, and mercury. However, it has not yet been determined whether sediment from the Lower Passaic River will, in fact, be classified as a RCRA hazardous waste; this must be resolved by further investigation during design.

B.4.4.6 Impacts of the Lower Passaic River to Newark Bay

The Lower Passaic River is the main source of freshwater to Newark Bay and a major source of contaminants to the Bay as well. Solids delivered from the Lower Passaic River to Newark Bay contain contaminant levels similar to those found in surficial sediments of the Lower Passaic River. As a result, for several contaminants examined, the history of contamination observed in the Lower Passaic sediments is also observed in Newark Bay. For example, dated sediment cores for the Lower Passaic River (RM0.9 to RM7) are consistent with the observations by Bopp *et al.* (1991a and 1991b) and Chaky (2003) for Newark Bay, specifically that the major releases of 2,3,7,8-TCDD begin in the late 1940s to early 1950s and peak around the late 1950s to early 1960s. The history of Total DDT releases observed in the Lower Passaic River was also consistent with the observations for Newark Bay made by Bopp *et al*. The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace Lower Passaic River 2,3,7,8-TCDD contamination throughout the Newark Bay complex. Recent surficial samples from Newark Bay suggest the mixing of high ratio, high 2,3,7,8,-TCDD concentration sediments from the Lower Passaic River with somewhat lower ratio, lower concentration sediments from the Arthur Kill and Kill van Kull, creating gradients in the ratio and the 2,3,7,8,-TCDD concentration across Newark Bay.

Mass balance analyses performed on Newark Bay suggests that the Lower Passaic River contributes approximately 10 percent of the total amount of solids accumulating in Newark Bay, but more than 80 percent of the 2,3,7,8-TCDD accumulating in the Bay [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. No other single source delivers more than 10 percent of the total 2,3,7,8-TCDD load. A similar mass balance analysis for mercury shows that the Lower Passaic River sediments are responsible for approximately 20 percent of the total mercury load to Newark Bay.

B.4.5 Groundwater and Surface Water Contamination

Investigations to date and the EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] focused on sediment solids and chemicals that are predominantly associated with sediments. Because the COPCs and COPECs that are under consideration are particle-reactive and are dominantly transported when sorbed to solids, contaminated sediments are the probable source of these compounds in the surface water of the Lower Passaic River. For this reason, remediation of sediment contaminated by COPCs and COPECs through the Source Control Early Action will likely effect a significant decrease in dissolved concentrations of these contaminants. The importance of groundwater and other releases of contamination that can only contribute dissolved phase constituents were not evaluated as a component of the EMB.

B.4.6 Models Used to Further the CSM

B.4.6.1 Empirical Mass Balance (EMB) Model

A chemical mass balance approach similar to USEPA's Chemical Mass Balance (CMB) model (Watson *et al.*, 2004) was used for the Lower Passaic River EMB Analysis. The USEPA CMB model is applied in air pollution studies for particulate matter and volatile organic compounds. Recently, CMB-type formulated models have been applied to sediment contamination sites that are contaminated with PCB, PCDD/F, and PAH compounds. Examples of these sediment contamination sites include Fox River in Wisconsin (Su *et al.*, 2000), Ashtabula River in Ohio (Imamoglu *et al.*, 2002), Lake Calumet in Chicago (Bzdusek *et al.*, 2004), and Tokyo Bay and Lake Shinji in Japan (Ogura *et al.*, 2005).

The input parameters to the EMB were the measured concentrations of the various chemicals in the different sources of contamination to the Lower Passaic River. Furthermore, watershed solids yield and watershed areas available from the United States Geological Survey (USGS) were used to formulate model constraints. The chemical signatures of the contamination sources were derived from several data collection programs, which are listed in Table B.4-7.

Table B.4-7: Field Sampling Programs Considered in the EMB

Source or Receptor	Field Sampling Program Considered	Number of Locations
Lower Passaic River	2005 USEPA High Resolution Sediment Coring Program	5
	2007/2008 USEPA Surface Sediment Sampling Program	16
Newark Bay	2005 TSI Remedial Investigation Phase 1 dataset	16
Upper Passaic River	2007 USEPA Sediment Coring Program	2
	2005 Rensselaer Polytechnic Institute Coring Program	2
	2007/2008 USEPA Surface Sediment Sampling Program	6
Tributaries	2007/2008 USEPA Surface Sediment Sampling Program	12
	2007/2008 USEPA Water Column Sampling Program	2
CSO/SWOs	2007/2008 USEPA Water Column Sampling Program	4

The uncertainty and variability in the measured concentrations used in the EMB (both source profiles and receptor concentrations) were evaluated using a sensitivity analysis, which involved iron-normalizing source and receptor concentrations, removing PAHs from the optimization, using the southern Newark Bay samples to represent the Newark Bay contribution, separating SWOs from the Second River source, and using Minimum Variance Unbiased Estimate (MVUE) instead of a simple mean to estimate the contribution from each source and the resulting concentration in the receptor. In all, a total of 9 separate runs were made with the model using variations of these parameters.

The contribution of resuspension of legacy sediments to the total solids load in the Lower Passaic River varied from 41% to 50% in these sensitivity runs. Newark Bay and the Upper Passaic River contributed roughly equal portions of the load, varying from 19% to 37% for Newark Bay and 15% to 30% for the Upper Passaic River. The tributaries and the CSO/SWOs contributed minor portions of the solids load, varying from 3% to 7% when combined.

On the face of it, the major conclusion from the EMB is that the legacy sediments of the Lower Passaic River and their associated contaminants are the most significant source of the important COPCs/COPECs to the river and Newark Bay, and represent an important contaminant source to the New York Harbor Estuary. As such, a remedy which addresses this source will significantly affect the state of the estuary. While there are other sources of COPCs/COPECs to the river, the EMB shows that they do not have nearly the same importance as the Lower Passaic River sediments, regardless of mechanism. Although arguments can be made that may slide the relative positions of individual sources within this hierarchy, no arguments can be made that will move the Lower Passaic River sediments from their position as clearly the most important. For this reason, the EMB stands in support of an early action. Further, the EMB shows that by isolating the sediments of the Lower Passaic River from the estuary, the related mechanisms at work in the Lower Passaic River will be significantly diminished, and the recovery of the system will be enhanced and expedited.

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B.4.7 Hydrodynamic Conditions on the River

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Contaminant concentrations in recently deposited sediments (Be-7 bearing sediments) obtained along the length of the Lower Passaic River show little or no trend with river mile, despite different loading histories and different source areas for the large number of contaminants associated with the sediments of the Lower Passaic River. Based on the 2007 surface sediment sampling program, recently deposited sediments between RM2 and RM12 are the most similar while locations upstream and downstream of this interval show more substantive contaminant concentration gradients with river mile. The lack of trend in Be-7 bearing sediments over such a long distance (RM2-RM12) is likely the result of tidal mixing, which gathers and commingles solids from the freshwater flow as it resuspends sediments throughout the river on both rising and falling tides.

Solids transport in estuarine settings has been extensively studied (see Geyer et al., 2001 for example) and is briefly described here. Because of the higher density of saline water, the incoming tide tends to flow in under the outgoing freshwater flow, forming a "salt wedge" of partially stratified water. This wedge moves up and down the river with the tide, with the most saline, densest water remaining at the bottom of the water column.

The high tidal velocities associated with the daily movement of the salt wedge serve to resuspend and transport surficial sediment particles. Due to the countercurrent flow between the freshwater and the salt wedge, the salt wedge tends to gather suspended matter, slowing and reducing its transport out to Newark Bay. The movement of the salt wedge, responding both to tidal forcing and variations in freshwater flow, mixes suspended solids along the river, which are variously transported with the currents in the freshwater flow, slowed and accumulated by the countercurrent flow of the salt wedge, and resuspended both by freshwater and saline flows where they interact with the sediment bed.

The farthest upriver extent of saline water in an estuary is referred to as the salt front. This location occurs where "sea salt" is first easily detected in the river and defined as a measured salinity of 0.5 parts per thousand, or "per mil" (‰) (USEPA, 2003). (The data are often presented in "psu," or practical salinity units, which are equivalent to parts per thousand.)

The data from several salinity probes placed at points along the Lower Passaic River between RM1.4 and RM9.8 were used to analyze the movement of the salt front in the Lower Passaic River. The maximum daily salinity at each probe was compared to daily flow data from the Little Falls USGS station (http://waterdata.usgs.gov/nwis/sw) and a linear regression was developed at each probe for days with maximum salinities above 0.5 psu. The regression was then solved to determine the flow rate that would cause the salt wedge to just reach the location of the probe at high tide. A similar regression was developed for low tide. Figure B.4-17 compares the high tide and low tide relationships with flow side-by-side for all of the available probes. Evident in the diagram is the nearly parallel trend with flow for the two relationships. This comparison also permits an estimation of the daily tidal excursion. Under nearly all conditions, the tidal excursion is roughly 4 miles, nearly one quarter of the length of the Lower Passaic River.

Using 30 years of daily flow data from the Little Falls Station, a frequency distribution was developed for the daily salt front location. Using this distribution, several charts were prepared to represent the salt front migration and daily excursion in response to a range of flow conditions. These charts were prepared to represent the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles for flow. These charts are shown in Figure B.4-18. In these charts, the scale of the daily tidal excursion as well as the migration in response to flow is illustrated by color-coded regions along the river.

These analyses of the available salinity data show that the salt front moves up and down a significant portion of the Lower Passaic River. In a single day, the high tide and low tide salt front locations are generally 4 miles apart, representing tidal mixing over nearly one quarter of the length of the Lower Passaic River. The centroid of the daily tidal oscillation can move up and down the river rapidly, depending on the discharge from the Upper Passaic River and its rate of change. Based on the last 30 years of flow data and the estimates presented above, the high tide salt front location was above RM9.8 more than 20 percent of the time. Similarly, the low tide salt front was below RM2 over 20 percent of the time. On an annual basis, this would represent more than 4 months where the salt front oscillation was at either end of the river. The other 60 percent of the time the salt front is estimated to range between RM2 and RM10, with a daily 4-mile tidal excursion. Thus, much of this interval is subject to frequent tidal mixing throughout the year.

B.4.8 Hydrodynamic Modeling

An analysis of output from the Lower Passaic River hydrodynamic model (HydroQual, 2008) was conducted as a second method for examining the location of the salt front and the hydrodynamic forces that result in the distribution of recently deposited contaminated sediments of the Lower Passaic River. Figure B.4.19 presents model output from the simulation period of March 1995 through September 2004. The river mile at which the high tide salinity concentration of 0.5 parts per thousand (ppt) was calculated is plotted against the river flow at Little Falls. The results of this analysis are similar to the findings of the empirical approach described above. As can be seen in Figure B.4-19, there is a log-normal relationship between river flow and the 0.5 ppt salinity river mile. During high-flow periods, when the flow is greater than 1000 cfs, the salt front rarely reaches beyond river mile RM8. During low-flow periods, the salt front can travel upstream as far as RM14 or RM15. During low-flow periods, the relationship between flow and river mile is not as strong as it is during high-flow periods. This is likely related to antecedent flow conditions, *i.e.*, the length of the low flow event and whether it occurred after a moderate- to high-flow event. River flow statistics reported at Little Falls during this period (March 1995-September 2004) indicate that the median flow is approximately 610 cfs. Based on this, Figure B.4-19 indicates that the upriver extent of the salt front would be between RM8 and RM10. The 20th percentile flow is approximately 132 cfs and Figure B.4-19 indicates that the high tide salt front could travel upriver as far as RM13 under this flow condition.

Additional analysis of the hydrodynamic model output was performed to assess the bottom water velocity and sediment grain shear stress, and their potential impact on the spread of contamination in the Lower Passaic River. Bottom shear stress is an important parameter because it is a key factor in determining the potential for resuspension of bottom sediments and remobilization of contaminated sediments. Figures B.4-20 through B.4-22 present probability distributions of hourly velocities and grain shear stresses at several locations along the river. The hourly velocities are averaged over the bottom five layers, or bottom half, of the model water column. Average velocities in the upriver direction are considered to represent the flood tide, and average velocities in the downriver direction are considered to represent the ebb tide. As one travels upriver from the mouth toward Dundee Dam the number of five-layer average ebb velocities begins to significantly outnumber the flood velocities, reflecting the upriver limit of tidal behavior. Shear stresses were calculated using the bottom layer velocities and a representative D_{50} at each segment.

Figure B.4-20 presents the probability distributions for flood and ebb tides. The probability distributions show that the calculated ebb and flood velocities and shear stresses between RM3 (2.97) and RM7 (6.93) are quite similar to one another, except at about the 99th percentile. At the 99th percentile at RM6 (6.06) and RM7 (6.93) the ebb velocities and shear stresses are higher than the flood velocities and shear stresses. Figure B.4-21 shows that by RM10 (9.98) the difference between the flood and ebb velocities becomes more pronounced. At RM12 (11.97), as shown in Figure B.4.8.4, there is almost complete separation between the flood and ebb probability distributions. However, upstream velocities of 0.25 m/sec or greater still occur approximately 15 percent of the time. The difference between the two probability distributions becomes even more pronounced farther upriver. However, the probability figures also show that even upriver of RM12 there are occasionally flood tide velocities high enough to carry suspended materials farther upstream.

The results of the bottom velocity and shear stress analysis (Figures B.4-20 and B.4-21) indicate that between RM0 and RM10 the flood and ebb velocities and shear stresses are relatively similar, and thus could resuspend and disperse sediment upriver and downriver to the same degree. Between RM10 and RM12 (Figure B.4-22) there is a transition where the ebb velocities and shear stresses begin to be larger than the flood velocities and shear stresses. Above RM12, the ebb velocities and shear stresses are clearly larger than the flood velocities and shear stresses. However, above RM12 there are still, on rare occasions, flood velocities high enough to transport material farther upriver.

B.4.9 Areas of Archaeological or Historical Importance

Formal cultural resource surveys have not yet been conducted for the Lower Passaic River. However, a geophysical survey of the Lower Passaic River was conducted by Aqua Survey, Inc. (2006) along the majority of the 17-mile Study Area. One of the objectives of the survey was to provide archaeological data essential for complying with the National Historic Preservation Act of 1966 (as amended through 1992) and the Abandoned Shipwreck Act of 1987. Technologies employed in the geophysical survey included sidescan sonar, sub-bottom profiler, fathometer, magnetometer, real-time kinematic differential global positioning, shallow push coring, and deep vibracoring.

The sidescan sonar survey indicated the presence of one potentially historically significant submerged cultural resource located at approximately RM11.5. The item is a probable shipwreck and was identified as a sonar target with an associated magnetic anomaly. Note that this wreck is located outside of the Area of Focus for the Source Control Early Action.

Stage 1 and, likely, Stage 2 cultural resource surveys of the river bed will be conducted as part of the pre-design investigation. In addition to evaluation of the submerged river bed, mud flat and river bank areas that were not included in the geophysical survey due to shallow water depths should be assessed for the presence of historically significant artifacts and evidence of colonial/pre-industrial habitation and use. Based on the results of an initial survey in these areas, mud flats and the river banks may require further analysis in a Stage 2 investigation.

B.4.10 Summary of Conceptual Site Model

In summary, although the Lower Passaic River is a partially stratified estuary, the tidal excursion is sufficiently energetic that the water column remains well-mixed with respect to suspended solids. The tidal portions of the river have been subject to increased sedimentation rates resulting from historical dredging followed by decades of minimal maintenance dredging. The period of minimal maintenance dredging coincided with a period of significant discharge of industrial and municipal waste to the river. Subsequent re-filling of dredged channels due to the reduced maintenance during the period of industrial discharges and the combination of relatively well-mixed suspended matter and high deposition rates yielded thick sequences of contaminated sediment. For this reason, local variations in sediment contaminant inventory are primarily attributed to variations in depositional rates, and not proximity to local sources; however, the resolution of available data sets is not sufficient to eliminate the possibility of very localized areas of high contaminant concentrations in the immediate vicinity of point sources.

Recently deposited surface sediment concentrations in the Lower Passaic River are relatively homogeneous over long distances, with the range typically less than a factor of 3 along 12 miles or more of the river. The relative homogeneity of contaminant concentrations in the surface sediments over these large distances is a function of the energetic tidal mixing. Locally, however, spatial heterogeneity exists among sediment core data, indicating the presence of "hot zones" of the river on the scale of a mile or more. Surface concentrations of many contaminants (*e.g.*, 2,3,7,8-TCDD) are maintained at high levels by erosion and resuspension of older, more contaminated sediments within the Lower Passaic River. Conversely, the concentrations of several important chemicals (*e.g.*, PAH) receive a significant input from external sources above the head-of-tide. Concentrations of some contaminants, such as PCB, are maintained by both head-of-tide influences and resuspension of legacy sediments. The continued elevated surface concentrations, resuspension of historic inventory, and tidal exchanges with down-stream water bodies provide a continuing source of contaminants to Newark Bay and the remaining New York Harbor Estuary.

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B.5 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

B.5.1 Land Use

B.5.1.1 Current On-Site Land Use

The current land use characteristics of the banks of the Lower Passaic River are described in a Navigation Analysis [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] prepared by the USACE in support of the FFS. The Newark side of the river (*i.e.*, west and south bank) between RM0.0 and RM4.6 can best be characterized as fully industrially developed. The Harrison side (*i.e.*, east and north bank) in this reach of the river is occupied by the railroad tracks of the PATH system and by an intermodal container-handling facility. Transitional land use areas are located on both banks of the river upstream of the Jackson Street Bridge (RM4.6). The west bank in this area of the river is dominated by McCarter Highway (New Jersey Route 21. The east and north bank in this area of the river is being redeveloped for a combination of residential and recreational uses. Redevelopment transition can be seen at Clay Street in Newark on the west bank, where a complex of storage tanks appears to be in the process of being dismantled. McCarter Highway (New Jersey Route 21) continues north along the west bank of the river (RM4.6 – RM15.4) to Dundee Dam. The east bank of this segment of the river is characterized as recreational parkland (containing at least one small public marina and a few private docking facilities for recreational craft) as well as some residential and light commercial land use areas. A recent examination of the river from adjacent roads revealed no storage tanks or facilities for commercial cargo vessels upstream of the tanks at Clay Street.

Current land use immediately adjacent to the Lower Passaic River, including the area located within the 100-year and 500-year floodplains, is predominantly urban, with some scattered areas of forested land and wetlands (Figure B.5-1).

B.5.1.2 Current Adjacent/Surrounding Land Use

The current land use characteristics of New Jersey counties encompassing the Study Area are described below (Malcolm Pirnie, Inc., 2006a):

- Bergen County [RM8.8 to Dundee Dam, east bank]: Land use is 40 percent residential with 14 percent public and quasi-public open space and 12 percent undeveloped property. Commercial property accounts for only 3 percent of the total land use. Bergen County land use applies to the following communities in the Study Area: East Rutherford, Garfield, Lyndhurst, North Arlington, Rutherford, and Wallington. All of these communities are located upriver of the 8-mile Area of Focus.

- Passaic County [RM11.5 to Dundee Dam, west bank]: Land use is a combination of residential, commercial, and industrial properties. The communities of Passaic and Paterson are mixed-use urban areas with high population density. Passaic County land use applies to the communities of Clifton and Passaic. Both of these communities are located upriver of the Area of Focus.

- Hudson County [RM0 to RM8.8, east and north bank]: Land use is evenly mixed between residential, industrial, vacant property, and streets/right-of-way. Water occupies 9,840 acres or approximately one-fourth of the total area of the county. Hudson County land use applies to the communities of Harrison, Jersey City, Kearny, and East Newark. All of these communities abut the river in the Area of Focus.

- Essex County [RM0 to RM11.5, west and south bank]: Land use is highly industrialized, especially in the eastern part of the county abutting the river. Several colleges and universities are also located in the county. Essex County land use applies to the communities of Belleville, Newark, and Nutley. Of these, only Newark is located along the Area of Focus; the others are farther upriver.

B.5.1.3 Reasonably Anticipated Future Land Uses

Reasonably anticipated future land uses for land located immediately adjacent to the Lower Passaic River are described in Section B.5.2.2 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses."

B.5.2 Surface Water Navigation Requirements

The Lower Passaic River contains a federally authorized navigation channel (the dimensions of which are listed in Section B.5.2.1 "Current Federally Authorized and Constructed Navigation Channel" below). The most recent dredging of the river occurred in 1983, when approximately 540,000 cy of sediment were removed from the

predecisional -deliberative

lower portion of the river near Newark (Ianuzzi, *et al*., 2002). Since that time, sediment deposition in the navigation channel has reduced the available draft to less than its authorized depth.

According to *Land Use in the CERCLA Remedy Selection Process* (USEPA, 1995b), remedial alternatives developed during the RI/FS should reflect reasonably anticipated future land use(s). On the shores of the Lower Passaic River, land use and navigation use (and thus navigation channel depth) are very often linked. In order to evaluate the channel dimensions necessary to accommodate current navigation usage, USACE-New York District conducted a survey of commercial stakeholders along the Lower Passaic River [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. In order to evaluate the channel dimensions necessary to accommodate reasonably anticipated future usage of the river, the State of New Jersey conducted surveys of municipalities and other local organizations along the Lower Passaic River [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. The results of the USACE and State of New Jersey surveys are described below in Section B.5.2.1 “Navigational Channel Dimensions to Accommodate Current Surface Water Uses” and Section B.5.2.2 “Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses,” respectively. The current federally authorized and constructed navigation channel dimensions with width constraints are as follows:

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- RM0 to RM2.5: The federally authorized and constructed channel depth is 30 feet relative to mean low water (MLW). At RM1.2, bridge abutments of a formerly utilized railroad freight bridge limit the channel width to 145 feet. The Point-No-Point Swing Bridge at RM2.5 limits the channel width to 103 feet and limits vertical clearance to 16 feet at high water. Fixed span bridges (*i.e.*, bridges that do not open) in this portion of the river include the Conrail Bridge at RM0.75, the US Route 1 (Pulaski Skyway) Bridge at RM1.9, and the New Jersey Turnpike Bridge at RM2.5.

- RM2.5 to RM4.6: The federally authorized and constructed channel depth is 20 feet MLW. There are no fixed span bridges in this portion of the river.

- RM4.6 to RM7.1: The federally authorized channel depth is 20 feet MLW; however, the channel was only constructed to 16 feet MLW. There are no fixed span bridges in this portion of the river.

- RM7.1 to RM8.1: The federally authorized and constructed channel depth is 16 feet MLW. There are no fixed span bridges in this portion of the river.

- RM8.1 to RM15.4: The federally authorized and constructed channel depth is 10 feet MLW. Fixed span bridges in this portion of the river include the Union Avenue Bridge at RM13, the Main Street Bridge at RM13.9, the Second Street Bridge at RM14.5, and the 8^{th} Street Bridge at RM 15.

Since the 1940s, there has been little maintenance dredging above RM2. Consequently, the channel has extensively filled back in, particularly between RM2 and RM8. (Refer to Table B.5-1 for the existing depths of the navigation channel.)

B.5.2.1 Navigational Channel Dimensions to Accommodate Current Surface Water Uses

As part of their navigational analysis, the USACE conducted an evaluation of waterborne commerce conducted between 1980 and 2004 in the Lower Passaic River [Appendix F of the FFS; Malcolm Pirnie, Inc., 20082008 (anticipated)]. This analysis concluded that over 90 percent of cargo (mostly consisting of petroleum and petroleum products) transported along the river is carried in vessels loaded to less than 13 feet draft, with the exception of 13 records of vessels having 26-foot drafts in 2004. Because the bulk of these shipments occurred between RM0 and RM1.2 where the authorized and constructed depth is 30 feet, the analysis concluded that commercial navigation on the Lower Passaic River is most likely currently constrained by width rather than by depth. The width constraint is a design criterion: channel width should be at least five times the beam of the vessel for two-way traffic, and at least three times the beam of the vessel for one-way traffic, with beam defined as the width of a vessel at its widest point, usually mid-ship [USACE Navigational Analysis, Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Based on USACE data, the dimensions of a navigation channel within the lower eight miles of the Lower Passaic River that would accommodate the current usage are as follows:

- RM0 to RM1.2: The authorized depth should be maintained at 30 feet MLW based on United States Waterborne Commerce data that indicate 13 barges requiring 26-foot drafts were recorded in 2004.

- RM1.2 to RM2.5: The authorized depth should be a minimum of 16 feet MLW based on the 5.5-foot tidal range in the lower 2.5 miles of the Passaic River. If the constructed depth falls below this threshold, maintaining safe passage will impose operational limitations to the timing of commerce, requiring shipments to coincide with high tide.

B.5.2.2 Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses

Channel depths to accommodate future usage were considered by the State of New Jersey and were based on future use surveys for municipalities, an evaluation of market and land use scenarios for the Passaic River region, statewide economic and revitalization programs, as well as the USACE Navigation Analysis [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. The State's recommendations for a minimum depth requirement in each of the river reaches for future navigation are based on the three key pieces of information described below. These minimum depths would require maintenance in the future to preserve the uses stated.

Municipality Surveys for Future Use and Master Plans: Over 70 surveys were mailed to representatives (Mayors, Assemblymen, Senators, Congressmen) involved in planning for approximately 17 municipalities with the 17-mile Study Area. A total of 13 surveys were returned covering areas within Clifton, Rutherford, Nutley, East Rutherford, Belleville, Bloomfield, Kearny, East Newark, Harrison, Bayonne, and Elizabeth. In addition to the surveys, master plans from Newark, Harrison, Kearny, and Belleville were reviewed to identify potential future redevelopment initiatives. All surveys will be utilized for the overall FS and restoration planning for the entire 17-mile Study Area.

The surveys and master plans outline current and proposed land use patterns which are related to the overall depth required for such designated uses. The survey results indicate that the communities in the upper 9 miles of the Study Area want to enhance public access, preserve open space, and improve recreational uses (*e.g.*, boating, fishing, ecotourism, parks/fields) along the river. In addition, a number of non-profit organizations are working to improve waterfront access (*e.g.*, locations, adequate depths), provide facilities (*e.g.*, marinas, docks), and spearhead recreational regional events. The Lower Passaic and Saddle River Alliance has also proposed a Water Kayak and Canoe Trail from Pompton River (RM32) to the confluence with Newark Bay and up the Hackensack River. Future proposed use planning efforts are summarized in Figure B.5-2.

USACE-New York District Lower Passaic River Navigation Analysis: The USACE conducted an analysis of past, current, and potential use of commercial entities located on the Passaic River. This study did not attempt to predict future use by the commercial facilities. The results of the USACE analysis and the USACE's recommended minimum channel depths are discussed in Section B.5.2.1 "Navigational Channel Dimensions to Accommodate Current Surface Water Uses."

Additional Considerations for the State of New Jersey: The navigational recommendations of the State of New Jersey support the goals and objectives for many statewide programs, including: Brownfield Development, Portfields Initiatives, Smart

Growth Initiatives, Comprehensive Statewide Freight Planning, the Long Range Transportation Plan, Transportation Choices 2030, State Development and Redevelopment Plan, and the Liberty Corridor Initiative. These programs are important considerations for the State of New Jersey with respect to future economic revitalization and development of the region, which could be constrained if the future authorized depth of the channel were insufficient to support the associated navigational requirements.

The area within Newark's Industrial Zone adjacent to and downstream of RM3.6 is considered a prime location by the State of New Jersey to support mixed-use economic growth and revitalization. The area within this zone has been designated as the Lister Avenue Brownfield Development Area (BDA) and slated for remediation and reuse. Specifically, the area between RM2.5 and RM3.6 (Blanchard Street/Fairmont Chemical Redevelopment Area) has been identified as a potential site in the Portfields Program and may be used to support Port operations through the placement of warehouse distribution operations. Other areas within the BDA (*e.g.*, Sherwin Williams, the Diamond Alkali Superfund Site, Hilton Davis) are in earlier stages of planning with uncertainties associated with their specific redevelopment. Based on these uncertainties, the significant private investment in Brownfield redevelopment, and the State's alignment of programs encouraging Brownfield redevelopment, the State desires to preserve future growth potential for this area to the maximum extent possible. Several divisions within NJDOT (Statewide Planning, Freight Planning and Intermodal Coordination, Office of Maritime Resources and Project Planning and Development) have determined that the minimum depth recommendations presented in the NJDOT memorandum support the goals and objectives of several statewide programs.

<u>NJDOT Minimum Depth Recommendations</u>: The NJDOT's recommendations for minimum depth requirements in the lower eight miles of the Passaic River (*i.e.*, the Area of Focus) are summarized in Table B.5-1.

Table B.5-1: Summary of Current Navigational Depths and NJDOT's Recommended Navigational Depths [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]

Reach (RM)	Authorized Depth (feet)	Constructed Depth (feet)	Existing Average Depth and Range (feet)	Minimum Depth for Anticipated Future Use (feet)	Comments
0.0-1.2	30	30	Avg: 17.2 Range: 9.5-20.9	30	Maintain existing and future industrial use
1.2-2.5	30	30	Avg: 19.7 Range: 14.8-24.7	16	Preserve future potential industrial uses, brownfields, portfields
2.5-3.6	20	20	Avg: 15.2 Range: 13.0-18.4	16	Preserve future potential industrial uses, brownfields, portfields
3.6-4.6	20	20	Avg: 16.4 Range: 11.9-22.1	10	Future recreational and commercial services (*e.g.*, water taxis/ferries)
4.6-8.0	20 (RM4.6-RM7); 16 (RM7-RM8)	16	Avg: 15.7 Range: 5.1-21.9	10	Future recreational and commercial services (*e.g.*, water taxis/ferries)

- RM0.0 – RM2.5: The USACE has determined that current navigational use of the river could be accommodated by an authorized depth of 16 feet (vessels drafting 13 feet) within this reach. Waterborne Commerce of the United States data and current dredging permits indicate use by vessels requiring 26 feet. Based on the recent polling of existing users and examination of current permitted berth dredging, it appears that there is a need for commercial drafts of at least 26 feet today, specifically near the confluence of Newark Bay. Since current users of the river are located in the lower 1.2 miles of the river, the depth requirements for this reach could be divided into two segments:

  - RM0.0 - RM1.2: Facilities that are currently using the river justify maintaining the current authorized depth of 30 feet. The State of New Jersey recommends maintaining the existing authorized depth of 30 feet in this segment.

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- RM1.2 - RM2.5: The depth is proposed to be not less than 16 feet based on future industrial users, brownfields, and portfields sites. Additional deliberation among the State of New Jersey and the cities of Newark and Kearny is planned to finalize the State's depth recommendation for this upper reach.

- RM2.5 – RM3.6: Although Newark's industrial zone above RM2.5 does not currently utilize the river for waterborne transportation purposes, the future plans for this segment may result in complete redevelopment of the area. The minimum depth requirement will be determined by future land use patterns following upland remediation. The State's recommendations consider the possibility of navigational use of the river for the Lister Avenue BDA, consistent with the Liberty Corridor Initiative, or for a use not yet identified. Therefore, the State has recommended a minimum depth of 16 feet in this segment to preserve the potential for future navigational use and economic revitalization of the region.

- RM3.6 – RM4.6: The State has recommended a minimum depth of 10 feet upstream of Newark's industrial zone and downstream of the Jackson Street Bridge. This depth is believed adequate to accommodate planned recreational and commercial services (*e.g.*, water taxis/ferries proposed at RM4.8) in the river as discerned from master plans and municipality surveys.

- RM4.6 – RM8.0: A primary goal of the Lower Passaic River Restoration Project is to improve public access and enhance recreational use of the river. The State's recommendations for river depths between Jackson Street and the Amtrak Bridge consider proposed water taxis/ferries within the river stretch. Future recreational uses and the possibility of commercial services (*e.g.*, water taxis/ferries) are considered for reaches upstream of the Amtrak Bridge. Most recreational vessels less than 30 feet in length have drafts of less than 3 feet; a depth of 5 feet would accommodate nearly all recreational vessels on the Passaic River. A minimum of

7 feet would accommodate all reasonably anticipated recreational uses. If commercial services considered a route upstream of the Amtrak Bridge, a depth of 10 feet would accommodate this potential need. It should be noted that limited bridge openings are a constraint for optimizing recreational use in the upstream reaches of the river.

Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses: In consideration of the USACE's Navigation Analysis evaluating channel dimensions necessary to accommodate current navigation usage and the State of New Jersey's recommendations for channel dimensions necessary to accommodate reasonably anticipated future usage [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], as well as permanent navigational constraints posed by bridges and bridge abutments, the USEPA has determined that the navigation requirements for the reasonably anticipated future use of the lower eight miles (*i.e.*, the Area of Focus) of the Lower Passaic River are as follows:

- A navigation channel depth of 30 feet below MLW from RM0 to RM1.2. At RM1.2, the river is constrained by bridge abutments of a formerly utilized railroad freight bridge. These abutments limit the channel width to 145 feet.

- A navigation channel depth of 16 feet below MLW from RM1.2 to RM1.9. At RM1.9, navigation would be constrained by the US Route 1 (Pulaski Skyway) Bridge, which is a fixed-span bridge (*i.e.*, a bridge that does not open).

B.6 SUMMARY OF SITE RISKS

B.6.1 Human Health Risk Assessment Summary

The full HHRA is presented in Appendix C of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]. Consistent with the NCP (USEPA, 1990), cancer risks and noncancer health hazards were estimated for current and future exposures, assuming reasonable maximum exposures (RMEs) and CTEs to assist in the decision-making process. The evaluation examined complete exposure pathways for chemicals most likely to pose the greatest risk to specific receptors for the lower eight miles of the Study Area in the near future. The assessment provides the basis for evaluating the value of an early remedial action; it is not intended to be a complete baseline risk assessment that includes an assessment of risks for all chemicals, receptors, and exposure pathways.

B.6.1.1 Risk Assessment Conceptual Site Model

A human health CSM of the Passaic River site is presented as Figure A-1 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary." The model shows sediment as a continuing source of contamination to the water column and biota through aquatic and benthic food chains. The COPCs in the sediment include PCBs, dioxins, pesticides, DDD, DDE, DDT, dieldrin, chlordane, and methyl mercury. For the purposes of this HHRA, only those chemicals, receptors, and exposure pathways most likely to pose the greatest risk were considered (refer to Table A-1 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary"). The COPCs evaluated in the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] represent those compounds that are considered to be most bioaccumulative, most persistent in the environment, and relatively toxic to human and ecological receptors. In addition, these COPCs represent the contaminants that have triggered states to issue fish and shellfish consumption advisories or bans (USEPA, 2000; USEPA, 2005a). The USEPA (2005a) reports that advisories have been issued in the United States for 36 chemical contaminants; however, 98 percent of these advisories in effect in 2004 involved five bioaccumulative chemicals including mercury, PCBs, chlordane, dioxins, and DDT, all of which are contaminants in the Passaic River.

B.6.1.2 Types and Characteristics of Contaminants of Potential Concern

General toxicity information for the COPCs evaluated in the HHRA is provided below. Additional information on the toxicity values used in the calculations of noncancer health hazards and cancer risks is provided in Table A-2 and Table A-3, respectively, in Appendix A “Supporting Tables for Human Health Risk Assessment Summary.” Except where noted, the toxicity values were obtained from the Integrated Risk Information System (IRIS), USEPA’s consensus toxicity database. This approach is consistent with the hierarchy of toxicity values identified in the USEPA OSWER Directive 9285.7-53 (USEPA, 2003a).

Dioxins: Dioxin toxicity varies greatly among the different congeners and is dependent on a number of factors. Dioxin is classified by USEPA as a Group B2 carcinogen (a probable human carcinogen) based on animal studies and human epidemiological evidence. The most common health effects in people exposed to large amounts of dioxin are chloracne and skin rashes, skin discoloration, and possibly mild liver damage. The cancer toxicity value for dioxin [150,000 milligrams per kilogram per day (mg/kg-day)] from the Health Effects Assessment Summary Tables was used in the calculation of risk. This value was selected because updated information was not available at the time this report was prepared. The USEPA is currently re-assessing the toxicity of dioxins and related compounds and addressing comments from the 2006 National Academy of Sciences evaluation of USEPA’s 2003 dioxin re-assessment. In July 2006, the World Health Organization (WHO) released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005, and these values were incorporated into the risk assessment (Van den Berg *et al.*, 2006).

PCBs: PCB toxicity also varies greatly among the different congeners and is dependent on a number of factors. The assessment evaluated both the dioxin-like (*i.e.*, structurally similar to dibenzo-p-dioxins) and non-dioxin like PCBs (USEPA, 1996). Responses to PCB exposure in animals include wasting syndrome, hepatotoxicity, immunotoxicity, neurotoxicity, reproductive and developmental effects, gastrointestinal effects, respiratory effects, dermal toxicity, and carcinogenic effects. Some of these effects may be manifested through endocrine disruption, and this is an area of continuing research by several federal agencies, including USEPA. USEPA classifies PCBs as probable human carcinogens (Group B2), based on several studies in animals showing liver tumors with exposure to a number of different PCB mixtures that are believed to span the range of congeners found in environmental mixtures (USEPA, 1996). Health effects of PCBs are identified in several USEPA and Agency for Toxic Substance and Disease Registry (ATSDR) documents (ATSDR, 2000; USEPA, 1996). There are several ongoing national and international studies assessing the noncancer health effects of PCBs in children exposed *in utero* from maternal consumption of PCB-contaminated fish and perinatally to PCBs in other food sources (*e.g.*, Patandin *et al.*, 1999; Lanting, 1999). Significant correlations have been observed between perinatal exposure to PCBs and dioxins and adverse effects on growth, immunologic parameters, and neurodevelopment and behavior. The IRIS toxicity values for cancer (based on an oral cancer slope factor of 2 mg/kg-day and an oral reference dose [RfD] for Aroclor 1254) were used in the assessment of the noncancer health effects from exposure to PCBs.

<u>Mercury</u>: Mercury exists in both elemental and methylated forms in the environment. For this assessment, the IRIS RfD for methylmercury was used in the assessment. Methylmercury is a highly toxic substance, and the most extensive data are available on neurotoxicity, particularly in developing organisms. The nervous system is considered to be the most sensitive target organ and was the basis for the derivation of the RfD.

<u>Pesticides:</u> DDT, dieldrin, and chlordane are associated with liver toxicity, and are all classified as Group B2 carcinogens. DDT is also a possible liver tumor promoter in rats. Chlordane is extremely lipid soluble, and lipid partitioning of chlordane and its metabolites have been documented in both in humans and animals. Recent epidemiological findings indicate that neurotoxicity may be a relevant human toxicological endpoint as a consequence of chronic as well as acute chlordane exposure.

B.6.1.3 Concentrations of COPCs in Each Medium

Measured chemical concentrations in environmental media were used to model chemical exposures for potential receptors. An exposure point concentration (EPC) represents "a reasonable estimate of the concentration likely to be contacted over time" (USEPA, 1989). Consistent with guidance, the EPCs used for this study were the 95 percent upper confidence limit (UCL) on the average for each COPC evaluated. The 95 UCL is typically recommended and used because of the uncertainty associated with estimating the true average concentration at a site. The EPCs were calculated following USEPA guidance (USEPA, 2002a). Specifically, the ProUCL Version 3.0 software package (USEPA, 2004) was used to determine the underlying data distribution for each chemical and then determine the most applicable EPC for that chemical based on the characteristics of the data. The program output provides a recommended UCL for the data. In cases when more than one UCL is recommended by the software program, the first recommended value was selected as the EPC. When evaluating data, one-half the detection limit was substituted for chemical concentrations below analytical detection limits (USEPA, 1989). The ProUCL output files for each of the COPCs are provided in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 [anticipated]). A summary of the EPCs is provided in Table A-4 and Table A-5 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" for fish and crab, respectively.

B.6.1.4 Potential Receptor Groups and Exposure Pathways

The Lower Passaic River is located in a highly populated area with diverse populations and may have undocumented subsistence anglers. Studies of anglers in the Passaic River and Newark Bay found that individuals are known to catch fish and crab along the river banks and from docks and bulkheads (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999). Currently, fish advisories exist in the Lower Passaic River (extending from the Dundee Dam to Newark Bay and along major tributaries to the river) that state "eat none" for fish and "do not harvest, do not eat" for crab. There are plans for future area development including public parks, which may increase the availability of recreational areas along the river for use by local residents and visitors.

The population of concern in the area of the Lower Passaic River consists of the inhabitants of the towns, cities, and industrial areas surrounding the river who may fish or engage in activities that bring them into contact with the river. Receptor groups were defined for this population to quantifying the potential COPC exposures within the population as a whole. Potential receptor groups and exposure pathways include anglers/sportsmen exposed to chemicals via ingestion of contaminated fish and shellfish, recreational users exposed to chemicals by direct contact with contaminated sediment and water, and homeless residents that may be exposed to chemicals by direct contact with environmental media and consumption of fish and shellfish. These receptor groups do not necessarily represent distinct population subgroups; rather, they are defined for convenience in presenting the exposure and risk analysis. The receptor groups are the same both for calculating current risks and estimating future risks for each of the remedial alternatives considered. The assumptions for exposure of these receptor groups are provided in the following sections.

B.6.1.5 Potentially Exposed Populations in Current and Future Scenarios and Sensitive Sub-Populations

As previously stated, undocumented subsistence anglers may use the Lower Passaic River, and studies have found that anglers/sportsmen are known to catch fish and crab (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999). The assessment of exposure risks from fish and crab consumption by the angler population includes an assessment of risks from consumption by young children (0 to 6 years), adolescents (10 to 18 years), and adults (19 years and older). Children represent a sensitive sub-population. Specific calculations were developed for young children (ages 0 to 6 years), assuming they consume fish caught and shared by the adult family members. Studies have found that children begin fishing at around 10 years of age (USEPA, 2000), so the adolescent age group was added to the assessment, as well. It is also possible that other distinct sub-populations may fish in the Area of Focus based on the identification of a homeless population in the area. These sub-populations may consume higher amounts of fish but are not explicitly identified in the creel surveys used in this analysis. This exposure route may be evaluated in the RI/FS for the 17-mile Study Area after further analysis of the creel surveys.

B.6.1.6 Exposure Routes

An exposure route is the mechanism by which a receptor is exposed to chemicals released to the environment. For anglers in the Lower Passaic River area, ingestion of fish that have bioaccumulated contaminants in their tissues (*i.e.*, dietary intake) is the exposure route evaluated. Section B.6.1.7 "Exposure Assessment" describes the exposure assumptions used for the fish-consuming population. Section B.6.1.8 "Non-Standard Exposure Assumptions (Ingestion Rates for Crab)" describes the exposure assumptions used for the crab-consuming population. For the purposes of this assessment, individuals were assumed to consume either fish or crab. Direct contact with COPCs in sediment and surface water during fishing and other recreational activities is another potentially complete exposure route; however, this pathway is not included in the FFS HHRA, but may be evaluated in the RI/FS for the 17-mile Study Area.

Only the angler receptor group was determined to have exposures resulting in unacceptable risks, and therefore only this group was examined in the FFS. The complete discussion of receptor groups examined, the exposure information evaluated, and associated cancer risks and noncancer hazards are presented in the HHRA (Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 [anticipated]). The collection and consumption of fish and shellfish from the Lower Passaic River has been well documented in a creel survey conducted by Belton *et al.*, (1985) for NJDEP, as well as in other published literature regarding anglers' perception of risk from contaminated fish (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999); therefore, it is clear that the exposure pathway for the angler/sportsman is complete. Individuals evaluated as "recreational anglers/sportsmen" were defined as those individuals (male and female) who consume self-caught fish from the Lower Passaic River. In the HHRA, it was assumed that adolescents and adults would fish and crab within the Area of Focus and that part of the fish and crab caught would be shared with younger children (ages 6 years and younger).

B.6.1.7 Exposure Assessment for Fish Consumption

A detailed description of the exposure parameters including major assumptions about exposure frequency, exposure duration, ingestion rates, body weights, and toxicity values is provided in the HHRA [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and associated Risk Assessment Guidance for Superfund (RAGS) Part D tables (USEPA, 2001). A summary of the exposure parameters is provided below. This section describes the exposure assessment for consumers of fish only.

<u>Ingestion Rates</u>: The RME (the 95th percentile) adult fish consumption rate used was 25 grams per day, or about 40 one half-pound fish meals per year as recommended in the EFH (USEPA, 1997). The recommended mean of 8 grams per day was used for the CTE (equivalent to approximately 14 one-half pound fish meals per year). The values recommended in the EFH are based on fish ingestion studies from several different freshwater locations across the United States. The ingestion rate for fish and crab identified in a more recent consumption survey (Burger, 2002) in the Lower Passaic River and Newark Bay found that 8 to 25 percent of the population ingested 1,500 grams per month, which is equivalent to 50 percent from fish and 50 percent from crab. This evaluation assumes that fish consumers ingested fish only.

The fish consumption rate used for the adult receptor was calculated from those recommended in Table 10-1 of the EFH (USEPA, 1997) for ages 20 to 70+ (intake averaged over six adult age groups). Ingestion rates used for the adolescent and child receptors were based on the assumptions that the intake for the adolescent is approximately two-thirds that of the adult and the intake for the child is approximately one-third that of the adult (USEPA, 1997). This is consistent with those presented in the EFH Table 10-1 for corresponding age groups 0 – 9 years and 10 – 19 years and also are within the upper bounds of the ingestion rates at the 90th percentile or above (USEPA, 1997). Therefore, for the RME, an ingestion rate of 8 grams per day is used for the child receptor, and 17 grams per day is used for the adolescent receptor.

Body Weight: Body weights used in the exposure assessment were adjusted to the appropriate age ranges of the individual receptor groups.

Exposure Duration: It was assumed that the adult receptor would live in the area for a total of 30 years (24 years as an adult and 6 years as a child) and that exposure to contaminants in fish tissue would occur throughout this duration. Risks were calculated as the sum of risks for an adult based on a 24-year exposure duration and a child for a 6-year exposure duration. For the adolescent receptor, it was assumed that this individual would be exposed for a period of 9 years, and this exposure was evaluated separately from the overall exposure duration for combined adult/child assessment.

Fish Species: Based on consumption data from the creel angler survey (Desvousges *et al.*, 2001), community surveys, and the historical analytical data available for each fish species, exposures were evaluated based on consumption of white perch and American eel. These two species represent the upper and lower bounds of fish tissue concentrations based on differences in trophic group (*i.e.*, predators and benthic-feeders) and contaminant bioaccumulation potential. Consistent with procedures used for the Hudson River assessment, an equal-weighted average concentration was calculated as the EPC for fish tissue.

EPCs: See Section B.6.1.3 "Concentrations of COPCs in Each Medium," and Table A-4 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" for fish EPCs.

Specific exposure parameter values used to estimate daily intake for the RME and CTE for ingestion of fish and crab for each of the receptors (adult, adolescent, and child) are summarized in Table A-6 through Table A-11 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary."

B.6.1.8 Exposure Assessment for Crab Consumption

Non-standard exposure assumptions were used for evaluating risks from the ingestion of crab. The EFH (USEPA, 1997) lacks data on the consumption rate of crab, and information in the published literature regarding the consumption rates of crab is limited. Studies conducted in the Passaic River and Newark Bay area were reviewed (Burger, 2002; Burger *et al.*, 1999; and May and Burger, 1996) to identify an appropriate consumption rate. Of the studies reviewed, only the 2002 Burger study contained sufficient information regarding crab consumption in the area of the Lower Passaic River, which was used to derive a consumption rate for this Risk Assessment.

<u>Ingestion Rates</u>: A yearly consumption rate for self-caught crab was developed (Burger, 2002) by multiplying the number of crab meals eaten per month by the number of crab eaten at each meal by the number of months per year during which crab are caught. Crab fishing is seasonal because crab activity declines during the colder months. During these months, crabs will move off-shore and into the deeper channels where they are inaccessible to fishermen. Therefore, consumption of crab was assumed to occur for three months each year. Based on the crab consumption patterns for receptors consuming crab only, the RME ingestion rate for the adult angler/sportsman was calculated as 23 grams per day (or approximately 35 one half-pound crab meals per year). This value is the 95 percent UCL of the yearly consumption value (assuming the average serving size from one crab is 70 grams).

Ingestion rates for the child receptor were estimated assuming a rate of one-third the adult ingestion rate. The ingestion rates for the adolescent receptor were estimated using two-thirds of the adult ingestion rate.

<u>Body Weight</u>: Appropriate adjustments in body weight were made to reflect the younger age of the child and adolescent receptors, as well.

Exposure Duration: It was assumed that the adult receptor would live in the area for a total of 30 years (24 years as an adult and 6 years as a child) and that exposure to contaminants in fish tissue would occur throughout this duration. Risks were calculated as the sum of risks for an adult based on a 24-year exposure duration and a child for a 6-year exposure duration. For the adolescent receptor, it was assumed that this individual would be exposed for a period of 9 years, and this exposure was evaluated separately from the overall exposure duration for combined adult/child assessment.

Species: For crab tissue, only the blue crab is of interest because it is the only commonly caught and consumed crab in the Lower Passaic River. This is reflected in the NJDEP state consumption advisories (NJDEP, 2006a; NJDEP, 2006b).

EPCs: For the purposes of this Risk Assessment, human exposure to COPCs in the hepatopancreas and muscle is anticipated based on crab cooking practices. Therefore, analytical results for both types of tissue samples were combined and used to determine the EPC for crab consumption, similar to the composite sample approach described in NJDEP guidance. Section B.6.1.3 "Concentrations of COPCs in Each Medium" provides information on how EPCs were calculated, and Table A-5 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" contains EPC data for crabs.

B.6.1.9 Summary of HHRA Results and Uncertainties

The HHRA was conducted consistent with USEPA guidance, guidelines, and policies (USEPA 1986; 1989; 2001; 2002a; 2000b). The application of these procedures is designed to reduce potential uncertainty and ensure consistency associated with assessment methods. Results are best estimates based on the most recent information and techniques available for evaluating and predicting risk. Based on the results from the RME assessment, total current cancer risks for all receptors from the ingestion of fish and crab are approximately 65 percent from TCDD TEQ (PCDD/F), 20 percent from TCDD TEQ (PCBs) and 10 percent from total PCBs. The risk for chlordane was estimated at 1 x 10^{-4}, contributing approximately 1 percent to the total risk.

Results of the HHRA show that under the current baseline conditions, cancer risks and noncancer hazards are expected to be above USEPA's generally acceptable levels for the 30- year period from 2007 to 2037. Chemical-specific summaries of RME and CTE cancer risk and noncancer health hazards are provided in Table A-12 through Table A-17 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" for each receptor. Table B.6-1 summarizes the RME risks for these populations for specific chemicals.

Table B.6-1: Summary of the Current RME Cancer Risks to the Child, Adolescent, and Adult Consumers of Fish and Crab from the Lower Passaic River

Chemical	Risk for Child [1]	Risk for Adolescent [2]	Risk for Adult [3]	Total Risk for Adult and Child
Fish				
TCDD TEQ (PCDD/F)	2×10^{-3}	1×10^{-3}	5×10^{-3}	6×10^{-3}
TCDD TEQ (PCBs)	6×10^{-4}	5×10^{-4}	1×10^{-3}	2×10^{-3}
Total PCBs	3×10^{-4}	3×10^{-4}	8×10^{-4}	1×10^{-3}
4,4'-DDD	2×10^{-6}	1×10^{-6}	4×10^{-6}	6×10^{-6}
4,4'-DDE	5×10^{-6}	4×10^{-6}	1×10^{-5}	2×10^{-5}
4,4'-DDT	1×10^{-6}	1×10^{-6}	3×10^{-6}	4×10^{-6}
Total Chlordane	3×10^{-5}	2×10^{-5}	8×10^{-5}	1×10^{-4}
Dieldrin	2×10^{-5}	2×10^{-5}	5×10^{-5}	7×10^{-5}
Methyl mercury	ND	ND	ND	ND
Total	3×10^{-3}	2×10^{-3}	7×10^{-3}	1×10^{-2}
Crab				
TCDD TEQ (PCDD/F)	1×10^{-3}	1×10^{-3}	3×10^{-3}	5×10^{-3}
TCDD TEQ (PCBs)	3×10^{-3}	2×10^{-3}	7×10^{-3}	1×10^{-2}
Total PCBs	5×10^{-4}	4×10^{-4}	1×10^{-3}	2×10^{-3}
4,4'-DDD	2×10^{-6}	1×10^{-6}	4×10^{-6}	5×10^{-6}
4,4'-DDE	5×10^{-6}	4×10^{-6}	1×10^{-5}	2×10^{-5}
4,4'-DDT	4×10^{-6}	3×10^{-6}	9×10^{-6}	1×10^{-5}
Total Chlordane	6×10^{-7}	5×10^{-7}	1×10^{-6}	2×10^{-6}
Dieldrin	1×10^{-5}	1×10^{-5}	3×10^{-5}	5×10^{-5}
Methyl mercury	ND	ND	ND	ND
Total	5×10^{-3}	4×10^{-3}	1×10^{-2}	2×10^{-2}

ND – not determined.
[1] Child (aged 1-6 years)
[2] Adolescent (aged 10-18 years)
[3] Adult (over 18 years of age)

Combined carcinogenic risks reflecting total exposure to chemicals in a given medium for a given exposure pathway are summarized in Table B.6-2.

Table B.6-2: Summary of the Combined Current CTE and RME Cancer Risks for Receptors (Child, Adolescent, and Adult) Consuming Fish and Crab from the Lower Passaic River.

Pathway	CTE	RME
Fish Ingestion - cancer		
Adult [1]	4×10^{-4} (4 in 10,000)	7×10^{-3} (7 in 1,000)
Child [2]	2×10^{-4} (2 in 10,000)	3×10^{-3} (3 in 1,000)
Total	6×10^{-4} (6 in 10,000)	1×10^{-2} (1 in 100)
Adolescent [3]	2×10^{-4} (2 in 10,000)	2×10^{-3} (2 in 1,000)
Crab Ingestion - cancer		
Adult [1]	3×10^{-3} (3 in 1,000)	1×10^{-2} (1 in 100)
Child [2]	1×10^{-3} (1 in 1,000)	5×10^{-3} (5 in 1,000)
Total	4×10^{-3} (4 in 1,000)	2×10^{-2} (2 in 100)
Adolescent [3]	2×10^{-3} (2 in 1,000)	4×10^{-3} (4 in 1,000)

[1] Adult (over 18 years of age)
[2] Child (aged 1-6 years)
[3] Adolescent (aged 10-18 years)

The potential for non-carcinogenic RME health hazards as quantified by the hazard quotient (HQ) for each chemical in each exposure medium for each exposure pathway, as appropriate, is summarized in Table B.6-3. The hazard index (HI), which is the sum of all the HQs, also is provided for each receptor for each medium.

Table B.6-3: Summary of the Current RME Non-Carcinogenic Hazards for the Child, Adolescent, and Adult Consumers of Fish and Crab from the Lower Passaic River

Chemical	Noncancer HQ for Child [1]	Noncancer HQ for Adolescent [2]	Noncancer HQ for Adult [3]
Fish			
TCDD TEQ (PCDD/F)	ND	ND	ND
TCDD TEQ (PCBs)	ND	ND	ND
Total PCBs	95	52	61
4,4'-DDD	ND	ND	ND
4,4'-DDE	ND	ND	ND
4,4'-DDT	0.1	0.05	0.05
Total Chlordane	2	1	1
Dieldrin	0.3	0.2	0.2
Methyl mercury	2	1	1
Total (*i.e.*, HI)	99	55	64
Crab			
TCDD TEQ (PCDD/F)	ND	ND	ND
TCDD TEQ (PCBs)	ND	ND	ND
Total PCBs	139	72	85
4,4'-DDD	ND	ND	ND
4,4'-DDE	ND	ND	ND
4,4'-DDT	0.3	0.1	0.2
Total Chlordane	0.04	0.02	0.02
Dieldrin	0.2	0.1	0.1
Methyl mercury	0.5	0.3	0.3
Total *(i.e.*, HI)	140	72	86

ND – not determined.
[1] Child (aged 1-6 years)
[2] Adolescent (aged 10-18 years)
[3] Adult (over 18 years of age)

The potential for combined non-carcinogenic effects in each medium and exposure pathway expressed as hazard indices, which reflect the potential additive effects of chemicals that affect the same target organ or system, is summarized in Table B.6-4. Quantitative analysis of the noncancer health effects from exposures to dioxins were not evaluated because of the lack of a toxicity value. This is an uncertainty that was addressed in the Risk Characterization.

Table B.6-4: Summary of the Combined Current Non-Carcinogenic CTE and RME Hazards Expressed as Hazard Indices for Receptors (Child, Adolescent, and Adult) Consuming Fish and Crab from the Lower Passaic River

HHRA Summary for the Passaic River – Fish/Crab Ingestion Pathway		
Pathway	CTE	RME

Fish Ingestion - noncancer		
Adult [1]	16	64
Adolescent [2]	14	55
Child [3]	25	99
Crab Ingestion - noncancer		
Adult [1]	60	86
Adolescent [2]	53	72
Child [3]	87	140
Total HI by Organ System for Ingestion of Fish [4]		
Child [3] – Immunotoxicity	24	95
Adolescent [2] – Immunotoxicity	13	52
Adult [1] – Immunotoxicity	16	61

[1] Adult (over 18 years of age)
[2] Adolescent (ages 10-18 years)
[3] Child (ages 1-6 years)
[4] Total PCBs were the only chemicals exceeding a HQ of 1 for crab ingestion; therefore, total HI for organ system has not been provided.

Significant sources of uncertainty inherent in the HHRA are identified in Table B.6-5 along with an indication of whether an overestimate or underestimate of cancer risk or noncancer health hazard may be expected.

Table B.6-5: Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks and Hazards

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks/Hazards
Exposure Assessment	EPCs for biota	95 percent UCLs on the mean were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk/hazard. The difference between the 95 percent UCL and mean indicates the level of uncertainty associated with EPC estimation.	If the sample mean is similar to or less than the population mean, using the 95 percent UCL will likely overestimate risk/hazard. If the sample mean is greater than the 95 percent UCL, risk/hazard will be underestimated.
	Chemical concentrations below analytical detection limits	A value ½ the detection limit was substituted for non-detect data.	Depending on the underlying data distribution, risk/hazard from some compounds with low frequency of detection may be underestimated or overestimated by using ½ the detection limit for non-detected values.
	Fish and crab tissue data used to derive EPC	Some historical data used to calculate the EPC for fish tissue may have included whole body samples rather than only fillets. Historical data used to calculate the EPC for crab incorporated the hepatopancreas results.	Incorporating all portions of the fish may overestimate fish tissue concentrations if, in fact, individuals tend to mainly eat fillets or muscle tissue. Risk/hazards for ingestion of crab may be overestimated because data from the hepatopancreas-specific samples were included in the EPC.
	Use of the white perch and American eel to derive the EPC for fish ingestion	Use of a weighted average fish concentration, consisting of white perch and American eel, was used to represent a broad range of fish species that could be caught and consumed. However, the assumption is that fish species are equally caught and consumed.	Risk/hazards may be overestimated or underestimated for individuals who consume only a single species. For example, risk/hazards for individuals who consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. A weighted average of the two fish species lowered the EPC. On the other hand, the risk/hazard for those individuals consuming only American eel would be overestimated. Relative effects on the risk/hazard calculation also depend on how similar tissue concentration in white perch and American eel are to tissue concentrations for other species of fish that may be consumed.
	Receptors and exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risk/hazards may be overestimated or underestimated for this site, depending on the accuracy of the assumptions used for the risk/hazard calculations.

	Receptors and exposure parameters	Ingestion rate for consumption of crab was based on a 3-month period during which individuals reported they caught crab.	This rate did not take into consideration the number of meals eaten throughout the year when individuals continued to catch crab beyond the 3-month period or ate crab that had been caught during the 3- month period and frozen. Therefore, risks/hazards may be underestimated.
		Other potentially complete exposure pathways for the anglers were not included (*e.g.*, dermal contact with sediment). In addition, exposure to dioxin and dioxin-like compounds in sensitive subpopulations such as breast-fed children was not evaluated.	Exclusion of these additional pathways may underestimate the risk/hazards if these are actual complete exposure pathways for the site.
Toxicity Assessment	Toxicity data (general)	Toxicity values for dioxin, PCBs, and mercury are based on an assessment of animal and human data. In some cases, animal data were used as the basis for the toxicity values that were further extrapolated to humans.	Because the most conservative values available are typically used, risks/hazards are more likely to be overestimated than underestimated.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	Risks using the 2005 TEF values were virtually equal to those based on the 1998 values and did not significantly affect risk/hazard calculations.
	Dioxin reassessment	USEPA is conducting a scientific reassessment of the health risks/hazards from exposure to dioxin and dioxin-like compounds in light of significant advances in scientific understanding of mechanisms of dioxin toxicity, significant new studies of dioxin's carcinogenic potential in humans, and increased evidence of other adverse health effects.	New information on cancer and noncancer effects may lead to the realization that risk/hazard calculations for this assessment either overestimated or underestimated cancer risks and noncancer health hazards.
Hazard Identification	Identification of COPCs for quantitative evaluation	Only a subset of contaminants that capture the primary risk/hazard drivers were carried through the risk/hazard assessment process.	Risks/hazards are underestimated.
		COPCs associated with other environmental media (*e.g.*, sediment and surface water) were not evaluated.	Risk/hazards are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data for biological tissue, results for mercury were used as surrogate for methyl mercury based on fate and transport properties of mercury in the environment and the toxicokinetics of mercury in the biota. This assumes that all mercury contained in fish and crab eaten by humans is present as methyl mercury.	Risk/hazards are likely overestimated.
Risk Characterization	Consumption of both fish and crab	Risks/hazards were evaluated assuming that the receptors ate fish or crab, but not both.	Risks/hazards may be underestimated for individuals who eat both fish and crab. However, for individuals who consume both crab and fish, the ingestion rates for each of these would be expected to decrease; therefore, risks/hazards would be overestimated if the same ingestion rates were assumed.

Table B.6-5: Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks and Hazards

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks/Hazards
	Thresholds that have been used for establishing consumption advisories	The information presented regarding the concentration of mercury in fish used to establish fish advisories for the general and vulnerable portions of the human population (*e.g.*, children and pregnant women) also identify potential concerns for the ingestion of mercury contaminated fish at varying concentrations.	Noncancer hazards may be underestimated for vulnerable portions of the population.

B.6.1.10 Conclusion

Commented [FB18]: In A.2, the text indicates this assessment was conservative…but that conclusion is not drawn here…should it be?

The results of the HHRA evaluation indicate that current cancer risks and noncancer health hazards exceed the NCP criteria for consumption of fish and crab. These results support the need for remedial action in the Lower Passaic River before fish consumption advisories can be relaxed. Remedial action would also help protect local populations that ignore fish consumption advisories and continue to consume fish caught from this area.

Commented [FB19]: Is it fairer to say "improvement" here, since MNR is hypothetically a possibility?

B.6.2 Ecological Risk Assessment Summary

The ERA conducted to support the FFS [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] evaluated direct contact exposures for sediment-associated receptors and indirect exposures to contaminated sediment (*i.e.*, bioaccumulation through the food web) for higher trophic levels (*i.e.*, consumers and predators). The indirect exposures evaluated bioaccumulation hazards for aquatic organisms that forage in the Lower Passaic River and wildlife that consume aquatic organisms from the Lower Passaic River. Receptors of interest include sediment-dwelling and epibenthic macroinvertebrates, pelagic and demersal fish, and piscivorous wildlife (*i.e.*, mink and great blue heron). The following sections provide a summary of the major elements of the ERA.

B.6.2.1 Identification of COPECs

The initial list of COPECs identified during the ERA can be found in the Pathways Analysis Report (Battelle, 2005). This list was refined based on information discussed during the Baseline ERA workshop held in 2006 in preparation for the development of the Draft Field Sampling Plan Volume 2 (Malcolm Pirnie, Inc., 2006b). The refinement process identified ten COPECs as comprising the largest contribution to total risk, and these ten COPECs were carried through this assessment. These compounds had HQs that exceeded 100 for inorganic compounds and 1,000 for organic compounds. Attachment 2 of the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] provides the complete screening process. The nine COPECs identified include the following:

- TCDD TEQ for PCDD/F
- Total PCB (sum of Aroclors)
- Total DDT
- Dieldrin
- LMW PAH
- HMW PAH
- Copper
- Lead
- Mercury (as methyl mercury)

For this assessment, surface sediment and biological tissue data collected from 1993 to the present were used to represent current conditions. Only surface sediment data from each sediment data set were used for the assessment. In some cases, the surface sediment was characterized as 0-6 inches; in other cases, it spanned from 0-1 foot. The largest surface sediment interval was 0-2.3 feet. Biological tissue data that were used consisted of blue crab, mummichog, American eel, and white perch samples. The analytical data for the American eel and white perch were combined (identified as AE/WP) to represent the consumption of multiple species by the upper-level trophic level receptors (*i.e.*, mink and great blue heron). Because a species-specific critical body residue (CBR) was unavailable for both species and because there was limited variation between the

American eel and white perch analytical data, the EPC that was derived for the AE/WP was also used to assess the potential risk to predatory fish from bioaccumulated body burdens. This is identified and discussed in Section 2.6.2.5 "Uncertainties Associated with the Ecological Risk Assessment."

B.6.2.2 Ecological Exposure Assessment

Receptors of Concern: A wide range of ecological receptors are potentially at risk from COPECs in the Lower Passaic River, including benthic invertebrates, fish, and a variety of aquatic-feeding avian and mammalian species. Table B-1 in Appendix B "Supporting Tables for Ecological Risk Assessment Summary" provides a summary of the ecological receptors evaluated, the associated exposure pathways, and the assessment and measurement endpoints. It should be noted that no aquatic threatened and endangered species are known to reside within the Study Area. The State of New Jersey has listed two avian species, the black crowned night heron and the American bittern, on the State's threatened and endangered species list. It is unknown whether these species are present in the Study Area.

EPCs: The exposure assessment determines the degree of co-occurrence between COPECs and the ecological receptors evaluated. As a component of this analysis, EPCs were calculated for each COPEC and exposure medium over the entire lower eight mile stretch of river (Area of Focus). These concentrations were used to calculate risk from direct contact exposure of non-wildlife receptors (*i.e.,* fish and invertebrates) with COPECs in sediment, indicental ingestion of contaminated sediment, and dietary exposures for wildlife receptors (*i.e.,* heron and mink) from consumption of contaminated prey. The analytical data for the COPECs are presented in Table B-2 through Table B-5 in Appendix B "Supporting Tables for Ecological Risk Assessment Summary," which provide summary statistics including the minimum, maximum, and mean values, frequency of detection, and the 95 percent UCL on the arithmetic mean. Separate calculations for were made for mudflat sediment samples to calculate risks to the great blue heron, which represents a piscivorous wading bird. The 95 percent UCL was used as the primary statistic for quantifying EPCs in the evaluation of current risks.

B.6.2.3 Ecological Effects Assessment

Three general categories of toxicological data were used to evaluate ecological risks:

- Sediment benchmarks: Sediment benchmarks that are based on the lowest concentration associated with ecologically-relevant adverse effects were used to evaluate direct contact sediment exposures for benthic macroinvertebrates and fish.

- Toxicity Reference Values (TRVs): TRVs are literature-based effects levels based on survival, growth and reproduction endpoints; these were used to estimate adverse effects to wildlife populations associated with contaminant exposure from the incidental ingestion of sediment and consumption of contaminated prey. Both no-observable-adverse-effects levels (NOAELs) and lowest-observable-adverse-effects levels (LOAELs) were used for the assessment.

- Critical Body Residues (CBRs): CBRs are literature-based effect levels for biological tissue and were used to estimate the potential for adverse effects associated with bioaccumulated tissue residues measured or estimated in benthic macroinvertebrates, fish, and avian eggs. Again, both NOAELs and LOAELs were used for the assessment.

B.6.2.4 Risk Characterization

The risk characterization combines the exposure assessment with the effects assessment to derive a quantitative estimate of risk. Most risks are calculated based on both NOAELs and LOAELs because effects thresholds are generally presumed to lie between these two values. Individual hazards to a given receptor from each chemical and exposure medium are calculated as a hazard quotient (HQ) such that:

$$HQ = EPC/toxicity\ value$$

where the toxicity values is either the screening benchmark, TRV or CBR. It is important to note the HQ is neither a measure of risk magnitude nor a measure of potential for adverse effects. It can only generally be stated that, for each receptor, COPEC and exposure medium, a larger HQ indicates a greater potential for adverse effects. The HQs for different COPECs, receptors and exposure media are not comparable. HQs can only be compared when chemicals share the same mechanism of effects; summing HQs to calculate a HI for individual receptors is based on the assumption that effects are additive.

Risks to benthic invertebrates exposed to Lower Passaic River sediments were evaluated based on sediment benchmarks developed for marine and estuarine ecosystems. The results are summarized in Table B.6-6. Copper, lead, mercury, PAHs, PCBs, dieldrin, DDT and TCDD TEQs all have hazard quotients that exceed 1.0. Sediment concentrations of TCDD TEQs for PCBs, copper and lead exceed screening benchmarks only marginally (HQs = 1.2 – 8). The HQs for sediment concentrations of mercury, PAHs and PCBs are somewhat higher (24 – 79). The greatest exceedences observed are for the pesticides (239 and 936 for DDT and dieldrin, respectively) and TCDD TEQs for dioxin (493 – 494). A separate evaluation that focused only on mudflat data yielded similar results, although EPCs and, consequently, hazard estimates were somewhat lower [see Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Exposure risk for macroinvertebrates was also evaluated based on CBRs. The evaluation compared measured tissue concentrations in blue crabs to NOAEL and LOAEL body residue concentrations that are associated with adverse effects on morality, growth, and reproduction. The details of these analyses are provided in Attachment 5 of the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and are summarized in Table B.6-7. Both the LOAEL- and NOAEL-based hazards were calculated. Copper, Hg, Total PCBs, DDT and the TCDD TEQs all have risk estimates that are bounded (*i.e.,* both the NOAEL- and LOAEL-based HQs were greater than 1.0), indicating a potential for adverse effects to benthic macroinvertebrates from exposure to these contaminants. Adverse effects from PAHs and dieldrin are possible but more uncertain because hazards from body burdens of contaminants are between the NOAEL and LOAEL (*i.e.,* the NOAEL-based HQ is greater than 1.0 and the LOAEL-based HQ is less than 1.0). Body burdens of lead do not pose risk to invertebrate receptors.

Risks evaluated for forage fish (mummichog) and for the larger AE/WP fish receptors were also based on a comparison of tissue residues to the applicable CBRs provided in Table B.6-8 and Table B.6-9. Again, both LOAEL- and NOAEL-based hazards were calculated for the two types of fish receptors using CBR data. For the mummichog (Table B.6-8), hazard estimates from body burdens of copper, lead, mercury and Total PCBs are all bounded (*i.e.,* both the NOAEL- and LOAEL-based HQs are greater than 1.0), indicating a potential for adverse effects. There is a potential for adverse effects to the mummichog from exposure to TCDD TEQ for dioxins/furans, however risks are more uncertain because hazard estimates from body burdens lie between the NOAEL and LOAEL (*i.e.,* the NOAEL-based HQ is greater than 1.0 and the LOAEL-based HQ is greater than 1.0). Hazards from bioaccumulated concentrations of PAHs, dieldrin, DDT and PCB TEQs are negligible (*i.e.,* both NOAEL- and LOAEL-based HQs are less than 1.0). For the AE/WP receptor (Table B.6-9), hazard estimates for all COPECs except PAHs, dieldrin, and PCB TEQs are bounded, indicating a potential for adverse effects. PAHs and the dioxin-like PCBs do not accumulate to levels that would cause adverse effects, and risk from dieldrin body burdens is possible but more uncertain.

Table B.6-6: Summary of Current Hazard Quotients for Benthic Invertebrates Based on Comparison of Sediment Exposure Concentrations with Screening Benchmarks

Habitat Type	Exposure Media	Chemical Parameter	Marine/ Estuarine Values		Lowest Sediment Benchmark [3] (µg/g)	Sediment EPC [4] (µg/g)	Hazard Quotient [5]	Assessment Endpoint
			NOAA ER-L [1] (µg/g)	NJDEP [2] (µg/g)				
Riverine/ Lower 8-Miles of Passaic River (AOF)	Main Channel and Mud Flat Sediment	Copper	34	34	34	236	6.9	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of benthic invertebrate communities that serve as a forage base for fish and wildlife populations.
		Lead	47	47	47	375	8	
		Mercury	0.15	0.15	0.15	3.6	24	
		LMW PAH	0.55	-	0.55	41	74	
		HMW PAH	1.7	-	1.7	61	36	
		Total PCBs (sum of Aroclors)	0.023	0.023	0.023	1.8	79	
		Dieldrin	0.00002	-	0.00002	0.019	936	
		Total DDT	0.0016	0.0016	0.0016	0.38	239	
		TCDD TEQ (PCDD/F)	0.0000032 [6]	-	0.0000032	0.0016 [7]	493	
		TCDD TEQ (PCBs)	0.0000032 [6]	-	0.0000032	0.000004 [7]	1.2	
		TCDD TEQ (Total)	0.0000032 [6]	-	0.0000032	0.0016 [7]	494	

ug/g = microgram per gram
[1] ER-L = Effects Range-Low from Long *et al.*, 1995.
[2] NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long *et al*. (1995).
[3] Minimum of the ER-L and the New Jersey sediment benchmark values.
[4] EPC is based on the 95 percent UCL on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
[5] HQ is the ratio of the EPC to the benchmark value.
[6] Derived by USFWS using sediment chemistry for the Arthur Kill and oyster effect data presented in Wintermyer and Cooper (2003).
[7] TEQ based on fish TEF.

Table B.6-7: Summary of Current Hazard Quotients for Benthic Macroinvertebrates Based on Comparison of Tissue Residue Concentrations with Critical Body Residue Concentrations

Habitat Type	Exposure Media	Chemical Parameter	Mean Blue Crab Body Burden (µg/g)	Macroinvertebrates		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine / Lower 8-Miles of Passaic River (AOF)	Sediment and Contaminated Prey	Copper	35	**410**	**41**	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of benthic macroinvertebrate communities that serve as a forage base for fish and wildlife populations.
		Lead	0.55	1	0.1	
		Mercury	0.09	10	1	
		LMW PAH	0.15	6.9	0.69	
		HMW PAH	0.16	74	0.74	
		Total PCBs (sum of Aroclors)	5.5	**13**	**5**	
		Dieldrin	0.022	2.2	0.28	
		Total DDx	0.56	**3,000**	**300**	
		TCDD TEQ (PCDD/F)	0.00022	**1500**	**170**	
		TCDD TEQ (PCBs)	0.000025	**170**	**19**	
		TCDD TEQ (Total)	0.00025	**1670**	**189**	

Bolded values indicate a potential for adverse effects as indicated by HQs > 1.0.

Table B.6-8: Summary of Current Hazard Quotients for Mummichog Based on Comparison of Tissue Residue Concentrations with Critical Body Residue Concentrations

Habitat Type	Exposure Media	Chemical Parameter	Mean Forage Fish Body Burden (µg/g)	Mummichog		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River (AOF)	Sediment and Contaminated Prey	Copper	3.9	**1,900**	**190**	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of demersal, benthivorous fish populations that serve as a forage base for fish and wildlife
		Lead	1.2	**45**	**4.5**	
		Mercury	0.041	**41**	**4.1**	
		LMW PAH	0.17	0.82	0.082	
		HMW PAH	0.065	0.31	0.031	
		Total PCBs (sum of Aroclors)	0.72	**160**	**16**	
		Dieldrin	0.0042	0.00033	0.00012	
		Total DDx	0.088	0.55	0.1	

		TCDD TEQ (PCDD/F)	0.00014	**2.2**	0.22	populations.
		TCDD TEQ (PCBs)	0.000064	0.027	0.0027	
		TCDD TEQ (Total)	0.0002	2.23	0.22	

Bolded values indicate a potential for adverse effects as indicated by HQs > 1.0.

Table B.6-9: Summary of Current Hazard Quotients for American Eel/White Perch Based on Comparison of Tissue Residue Concentrations with Critical Body Residue Concentrations

Habitat Type	Exposure Media	Chemical Parameter	Mean Predatory Fish Body Burden (µg/g)	AE/WP		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River (AOF)	Sediment and Contaminated Prey	Copper	25	**12,400**	**1,200**	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous, or semi-piscivorous fish populations that serve as a forage base for wildlife populations or sports fishery.
		Lead	0.63	**23**	**2.3**	
		Mercury	0.35	**350**	**35**	
		LMW PAH	0.17	0.82	0.082	
		HMW PAH	0.10	0.48	0.048	
		Total PCBs (sum of Aroclors)	3.4	**1,400**	**140**	
		Dieldrin	0.027	**2.5**	0.25	
		Total DDx	0.52	**13,000**	**290**	
		TCDD TEQ (PCDD/F)	0.00025	**7.4**	**4.3**	
		TCDD TEQ (PCBs)	0.0000051	0.15	0.088	
		TCDD TEQ (Total)	0.00026	**7.55**	**4.4**	

Bolded values indicate a potential for adverse effects as indicated by HQs > 1.0.
(1)TEQ based on bird TEF.
(2)TEQ based on mammal TEF.

Because embryo and juvenile life stages are among the most sensitive to contaminant exposure, risks to fish were also evaluated by comparing estimated fish egg TCDD TEQ concentrations with CBRs. The individual TCDD TEQs for PCBs and dioxins/furans were compared to the Lower Confidence Levels (LCLs) and UCLs for the 95% "species protection level" estimates of the fish egg species-sensitive distributions (SSD) (Steevens *et al.,* 2005) to estimate the HQs for dioxin/furan and PCB congeners; a total TCDD TEQ was then calculated as the sum of the two. The estimated LCL and UCL HQs for Total TCDD TEQ in American eel/white perch are 28 and 2.3, respectively; for mummichog the comparable values are 36 and 3.

Hazards calculated for the mink and the great blue heron are summarized in Table B.6-10 and Table B.6-11, respectively. For the mink, a diet consisting of 20 percent invertebrates and 80 percent piscivorous fish (*i.e.,* AE/WP) was assumed. Hazard estimates for Total PCBs and TCDD TEQs are bounded (*i.e.,* both the NOAEL- and LOAEL-based HQs are greater than 1.0), indicating a potential for adverse effects to mink from the ingestion of contaminated sediment and prey. Ingestion of contaminated fish is the risk driver, and only the TCDD TEQ for dioxins/furans in sediment poses unacceptable risk (NOAEL-based HQ=12 and LOAEL-based HQ=4.2). Risk from the ingestion of invertebrates is negligible for all COPECs (*i.e.,* all HQs were less than 1.0). Risk from exposure to copper is possible but more uncertain because only the NOAEL-based HQ was greater than 1.0, and the effects threshold lies somewhere between the LOAEL and NOAEL. Risks from exposure to lead, mercury, high molecular weight PAHs, dieldrin and Total DDx are negligible.

Table B.6-10: Summary of Ecological Risk Estimates for Mink

Habitat Type	Exposure Media	Chemical Parameter	Mink		Assessment Endpoint
			NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River (AOF)	Sediment and Contaminated Prey	Copper	**1.7**	1	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous mammal populations.
		Lead	0.52	0.27	
		Mercury	2	0.62	
		LMW PAH	--	--	
		HMW PAH	0.04	0.04	
		Total PCBs (sum of Aroclors)	**15**	**12**	
		Dieldrin	0.53	0.26	
		Total DDT	0.2	0.04	
		TCDD TEQ (PCDD/F)	**1,000**	**37**	
		TCDD TEQ (PCBs)	**560**	**20**	
		TCDD TEQ (Total)	**1560**	**57**	

Bolded values indicate a potential for adverse effects as indicated by HQs > 1.0.

Exposure risk for the great blue heron was evaluated assuming a diet of mummichog and some blue crab along with some incidental ingestion exposure to mudflat sediment during foraging (see Table B.6-11). Hazard estimates demonstrate that there is risk to piscivorous birds from exposure to TCDD TEQs, as the hazard estimates are bounded (*i.e.,* both the NOAEL- and LOAEL-based HQs are greater than 1.0), indicating a potential for adverse effects from the ingestion of contaminated sediment and prey. Risk from exposure to Total DDx, mercury and Total PCBs is possible but more uncertain because only the LOAEL-based HQ is greater than 1.0, and the effects threshold lies somewhere between the LOAEL and NOAEL. Risk from exposure to copper, dieldrin and PAHs is negligible.

The relative contribution of each dietary exposure medium varies for each COPEC. Overall, the consumption of contaminated fish and invertabrates contributes to the majority of the risks to the heron, accounting for as much as 95 percent of the total hazard estimate. Risks associated with incidental sediment ingestion are considerably lower than for the fish consumption pathway. As noted above, exposure to coplanar PCBs accounts for the majority of risk to the heron, risk estimates from the TCDD TEQ for PCBs being higher than those for the TCDD TEQ for dioxins and furans.

Table B.6-11: Summary of Ecological Risk Estimates for Great Blue Heron

Habitat Type	Exposure Media	Chemical Parameter	Great Blue Heron		Assessment Endpoint
			NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	0.47	0.16	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of aquatic bird populations.
		Lead	1.0	0.52	
		Mercury	2.6	0.26	
		LMW PAH	--	--	
		HMW PAH	--	--	
		Total PCBs (sum of Aroclors)	1.6	0.39	
		Dieldrin	0.01	0.0002	
		Total DDx	6.2	0.62	
		TCDD TEQ (PCDD/F)	15	1.5	
		TCDD TEQ (PCBs)	**45**	**4.5**	
		TCDD TEQ (Total)	60	6.0	

Current hazards were also calculated for piscivorous birds based on estimated egg residues, because the avian embryo is likely the most sensitive life stage. Pesticides, PCBs and dioxins/furans were determined to pose risk to avian receptors in the area from maternal transfer of contaminants to eggs. Risk results are presented in Table B.6-12.

Table B.6-12: Summary of Risks to Avian Piscivores Based on Estimated Gull Egg Residues

Chemical Parameter	Estimated Egg Tissue Concentration[1]	Units	LOAEL HQ[2]
Total PCBs (sum of Aroclors)	45	MG/KG	nc
Dieldrin	0.084	MG/KG	1.4
Total DDx	7.6	MG/KG	76
TCDD TEQ (PCDD/F)	0.0018	MG/KG	12
TCDD TEQ (PCBs)	0.0057	MG/KG	38
TCDD TEQ (Total)	0.0075	MG/KG	50

[1] Egg concentration for avian piscivore receptor (mg/kg wet weight) estimated by multiplying the Fish tissue concentration by the BMF and the ratio of the egg to fish percent lipid and the congener-specific TEF. The following lipid contents were assumed: 7.0 Average American eel/white perch lipid percent in Lower Passaic River samples. and 7.7 Average gull egg lipid percentage (Braune and Norstrom, 1989).

[2]Only LOAELs were identified; nc – not calculated..

B.6.2.5 Uncertainties Associated with the ERA

The ERA was conducted in accordance with USEPA guidance, guidelines, and policies. Significant uncertainties inherent in the risk assessment process are summarized in Table B.6-12. The table also identifies the projected impact of each uncertainty on the ERA conclusions (*i.e.*, whether the uncertainty results in an overestimate or underestimate of the calculated ecological hazard). Although conservative assumptions were employed throughout the assessment, the limited focus of the analysis indicates that there is a low to moderate level of uncertainty in the ERA and that, overall, the risk assessment tended to underestimate ecological hazards associated with these elements.

Commented [FB20]: We don't have a consistent approach to characterizing the results of the assessments…the HHRA summary is silent on whether it overestimates or underestimates…but in A.2 it is stated that it is "conservative"…can we make similar types of conclusions in each case?

Table B.6-13: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Problem Formulation	Identification of COPECs for quantitative evaluation	Only a subset of contaminants were selected and evaluated, and other contaminants are likely to be contributing to risk at the site, as well.	Risks are somewhat underestimated; however, exposures to the selected COPECs likely represent the majority of the total hazards posed to ecological receptors.
		COPECs associated with other environmental media (*e.g.*, surface water) were not considered in the evaluation.	Risks are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data for biological tissue, results for mercury were used as a surrogate methyl mercury. This assumes that all mercury bioaccumulated through the food chain is present as methyl mercury.	Although the hazards may be overestimated, the overall uncertainty is considered low because methyl mercury generally constitutes the majority of mercury bioaccumulated in fish tissue.
	Evaluated exposure pathways	Other potentially complete exposure pathways for fish and wildlife were not included in the assessment (*e.g.*, dermal contact with sediment; consumption of contaminated surface water). In addition, exposure to dioxin and dioxin-like compounds in sensitive critical life stages (*e.g.*, fish embryos) was not explicitly evaluated.	Exclusion of these additional pathways would underestimate the risks for the site.
	Receptors and life stage evaluated	Wildlife species with foraging habits other than piscivorous were not evaluated.	It is anticipated that wildlife consumption of aquatic prey, including fish and shellfish, would result in the highest dietary exposures to COPECs; it is likely that risk to other wildlife species are of lower magnitude than reported in this assessment.
Exposure Assessment	EPCs for biota tissue	95 percent UCLs were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk.	If the sample mean is similar to or less than the population mean, using th 95 percent UCL to calculate risk/hazard will likely overestimate risk/hazard. If the sample mean is greater than the 95 percent UCL, risk/hazard will be underestimated.

Table B.6-12: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Exposure Assessment	Chemical concentrations below analytical detection limits	A value ½ the detection limit was substituted for non-detect data.	Depending on the underlying data distribution, risk from some compounds with low frequency of detection may be underestimated or overestimated by using ½ the detection limit for non-detected values.
	Use of a AE/WP fish composite	Use of EPCs based on a combination of AE/WP tissue data to represent exposures to piscivorous wildlife assumes that they are from the Lower Passaic River and that each of these species is equally consumed.	Risk estimates for individual mink that consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. Averaging the two fish species would therefore dilute the EPCs. On the other hand, the risk for those individuals consuming only American eel would be overestimated. Exposures would also be overestimated to the extent that wildlife receptors consumed more migratory species such as striped bass, which tend to have lower tissue COPEC concentrations.
	Receptor exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risk estimates were based on conservative values derived from standard ecological risk guidance (USEPA, 1993a) or professional judgment. It is likely that hazards were overestimated because of the general tendency to select conservative values.
	Use of historical data	Sediment samples dating back to 1994 and biota tissue samples dating back to 1995 were used to develop EPCs in the assessment. These data are up to 12 years old and may not be representative of current conditions.	Inclusion of the historical data may tend to overestimate current exposures and hazards based on trends observed in sediment cores. Calculated multipliers to translate 1995 sediment concentrations to equivalent present-day concentrations range from 0.6 (total PCBs) to 1.0 (DDT); the estimated average multiplier for TCDD is 0.9. The use of historical data would have different impacts on the calculated risks, depending on which COPECs were identified as the primary risk drivers.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
	Wildlife diet composition	Literature was referenced to quantify the relative proportion of fish and shellfish in the diets of the modeled wildlife receptors.	Ranges of estimated values generally did not differ dramatically (ranging from 0 to 30 percent in different studies, depending on the particular habitat) and the tissue EPCs are fairly comparable. However, this uncertainty has more significance for the future residual risk analysis because of significant differences in the estimated bioaccumulation factors (BAF) for higher-trophic-level fish and shellfish.

Table B.6-12: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Exposure Assessment	Fish prey trophic level	Wading birds generally take smaller forage fish rather than larger, higher-trophic-status species. Concentrations in mummichog (a forage fish) are approximately an order of magnitude lower than in AE/WP.	Use of the fish EPCs based on a higher-trophic-level dataset likely overestimates risks to wading birds such as the heron. The magnitude of this impact was evaluated by also including an assessment of a diet that consisted of mummichogs.
Toxicity Assessment	Ingestion toxicity data	TRVs are typically based on results of tests performed on test animals and extrapolated to wildlife species; selected values are generally conservatively developed as the lowest LOAEL for well-conducted studies that evaluated ecologically relevant endpoints.	Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated. In the case of the mink receptor, well-conducted toxicity test results are available and were used to develop the TRVs.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	An evaluation of the hazards posed based on use of the 2005 TEF values demonstrates that they are comparable to those based on the 1998 values.
	CBR effect thresholds	CBRs were selected based on a review of several large compilations of tissue residue effect data. Study quality is variable and relevance of particular endpoints uneven relative to the assessment endpoints.	Likely risks were overestimated; however, suitable tissue residue data for certain COPECs were limited and may not have included relevant sensitive species or life stages.
		Use of toxicologically unbounded study results to develop CBRs.	In several cases, NOAELs were estimated using an assumed 10-fold extrapolation factor; this may have underestimated or overestimated hazards in the assessment.
		In general, the most sensitive saltwater or estuarine fish species was selected to develop the CBRs. In many cases, CBRs are based on exposure to salmonid species that are known to be sensitive to COPECs such as dioxins, DDT, and mercury.	Species such as salmon and trout are not found in the Lower Passaic River, and hazards identified in the residue-based analysis for the AE/WP are likely overestimated. A separate set of CBRs was also developed for estuarine forage fish such as *Fundulus* spp., and CBRs for these species were, in some cases, higher than for the AE/WP (such as those for TCDD and Total DDT).

B.7 REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

RAOs were established to describe what the cleanup is expected to accomplish, and PRGs were developed as targets for the cleanup to meet in order to protect human health and the environment.

Risks are driven by highly contaminated surface sediment in the Lower Passaic River, and the remediation of surface sediment to the levels established by the RAOs and PRGs will significantly reduce risk to both human and ecological receptors. In addition, reduction of the source of contamination will reduce risks in Newark Bay and harborwide.

B.7.1 Remedial Action Objectives

The RAOs were developed by the USEPA with input from the partner agencies regarding current and reasonably anticipated future uses of the site. The RAOs are as follows:

- Reduce cancer risks and noncancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of COPCs in fish and shellfish.

- Reduce the risks to ecological receptors by reducing the concentration of COPECs in fish, shellfish and benthic organisms.

- Reduce the mass of COPCs and COPECs in sediments that are or may become bioavailable.

- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

B.7.2 Preliminary Remediation Goals

PRGs provide long-term targets to use during analysis and selection of remedial alternatives. During the evaluation and development of PRGs, several human health and ecological risk-based concentration thresholds were considered. Ideally, such goals, if achieved, should both comply with ARARs and result in residual risks that satisfy the NCP requirements for the protection of human health and the environment.

B.7.2.1 Human Health Preliminary Remediation Goals

The human health PRGs were developed consistent with USEPA RAGS Part B (USEPA, 1991) and were based on the results of the HHRA [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. The PRGs were calculated considering the consumption rates for the adult consumer of fish and crab based on the exposure assumptions used in the HHRA and also recognizing background contributions of contaminants to the Lower Passaic River. Based on the comparability of the consumption rates for consumption of fish and crab (*i.e.*, 25 grams per day compared to 23 grams per day) one set of PRGs were developed, which are applicable to consumption of fish or crab.

The PRGs were developed for the adult angler who consumes fish or crab from the Lower Passaic River. The PRGs are summarized in Table B.7-1, which presents the risk-based PRGs for the fish concentration, and Table B.7-2, which provides the associated sediment concentration. For each COPC, the point of departure for cancer risks was calculated at 1 x 10^{-6} (one in one million), and the point of departure for noncancer health hazards was a HQ equal to 1. The calculated PRGs assume that the adult ingests 40 eight-ounce fish meals per year for 24 years [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. Because of a lack of available toxicity data, a PRG based on carcinogenic effects was calculated for Total PCB, but not for the TCDD TEQ (PCB), because: (1) the estimated risks for Total PCB and TCDD TEQ (PCB) are comparable, so that calculated PRGs using Total PCB and coplanar PCB congeners separately would not differ significantly; and (2) any remedial action based on Total PCB PRGs would address the presence of the dioxin-like PCB concerns based on co-location. Interim PRGs assuming lower rates of consumption (*i.e.*, 1 meal per year, 2 meals per year, 6 meals per year, and 12 meals per year) associated with New Jersey fish consumption advisory levels were also calculated (Table B.7-3 and Table B.7-4). This was done to provide concentrations for fish advisories that may be established as an institutional control as part of the Source Control Early Action and may be relaxed over time as sediment concentrations, fish body burdens, and human health risks are reduced. Calculations for all PRGs are presented in the Sediment TBCs and Development of Preliminary Remediation Goals [Appendix B of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Table B.7-1: Summary of the Human Health PRGs Developed for Fish/Crab Tissue

COPC	PRGs [1] for Fish/Crab Tissue for an Adult Angler			
	Cancer PRGs (ng/g)			Noncancer PRGs (ng/g)
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	
TCDD TEQ	0.000055	0.00055	0.0055	ND [2]
Total PCB	4.1	41	410	56
Chlordane	23	230	2,300	1,400
Methyl mercury	ND [3]			280

ng/g – nanograms per gram of sediment (1 ng/g = 1 µg/kg)
ND – not determined.
Values are presented at two significant figures.
[1] Assumes 40 eight-ounce fish or crab meals per year for 24 years.
[2] No toxicity values are available at this time.
[3] Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

Table B.7-2: Summary of the Human Health PRGs Developed for Sediment

COPC	PRGs [1] for Sediment			
	Cancer PRGs (ng/g)			Noncancer PRGs (ng/g)
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	
2,3,7,8-TCDD	0.00027	0.0027	0.027	ND [2]
Total PCB	1.9	19	190	26

Chlordane	1.2	12.0	120	72
Mercury	ND [3]			2,814

ng/g – nanograms per gram of sediment (1 ng/g = 1 µg/kg)
ND – not determined.
Values are presented at two significant figures.
[1] Assumes 40 eight-ounce fish or crab meals per year for 24 years.
[2] No toxicity values are available at this time.
[3] Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

Table B.7-3: Interim Human Health PRGs Developed for Fish/Crab Tissue

COPC	PRGs for Fish/Crab Tissue for an Adult Angler Based on the Number of Fish Meals[1] Per Year											
	Cancer PRGs (ng/g)									Noncancer PRGs (ng/g)		
	12 meals per year			2 meals per year			1 meal per year			12 meals per year	2 meals per year	1 meal per year
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$			
TCDD TEQ	0.00018	0.0018	0.018	0.0011	0.011	0.11	0.0022	0.022	0.22	ND[2]		
Total PCB	14	140	1,400	82	820	8,200	160	1,600	16,000	190	1,100	2,300
Chlordane	78	780	7800	470	4700	47000	940	9400	94000	4,700	28,000	56,000
Mercury	ND[2]									938	5628	11,256

ng/g – nanograms per gram of sediment (1 ng/g = 1 µg/kg)
ND – not determined.
Values are presented at two significant figures.
[1] 12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months.
[2] No toxicity values are available at this time.

Table B.7-4: Interim Human Health PRGs Developed for Sediment

COPC	BAF[1]	PRGs for Fish/Crab Tissue for an Adult Angler Based on the Number of Fish Meals[2] Per Year											
		Cancer PRGs (ng/g)									Noncancer PRGs (ng/g)		
		12 meals per year			2 meals per year			1 meal per year			12 meals per year	2 meals per year	1 meal per year
		$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$			
2,3,7,8-TCDD	0.20	0.00091	0.0091	0.091	0.0055	0.055	0.55	0.011	0.11	1.1	ND[3]		
Total PCB	2.2	6.0	60	600	40	400	4,000	75	750	7,500	85	500	1,000
Chlordane	20	4	40	400	24	240	2,400	48	480	4,800	240	1,400	2,900
Mercury	0.10	ND[3]									9,400	56,000	110,000

ng/g – nanograms per gram of sediment (1 ng/g = 1 µg/kg)
ND – not determined.

Values are presented at two significant figures.
[1]BAF = bioaccumulation factor; sediment PRG=tissue PRG/BAF.
[2]12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months.
[3] No toxicity values are available at this time.

B.7.2.2 Ecological Preliminary Remediation Goals

Separate PRGs were calculated for ecological receptors including benthic organisms and wildlife [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. Ecological PRGs were developed for copper, lead, mercury, LMW PAHs, HMW PAHs, Total PCBs, Total DDx, dieldrin, TCDD TEQ for PCDD/F, and TCDD TEQ for PCBs for benthic organisms (including bivalves and crab) and for estuarine-dependent wildlife[5] [refer to Appendix B of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. It was assumed that the PRGs developed for these two categories of receptors will be sufficiently protective of fish species as well. Sediment concentrations protective of benthic infauna exposed directly to various constituents were derived for marine and estuarine habitats by Long *et al*. (1995). These values, termed ER-L (effects range - low), represent the low end of a range of levels at which adverse effects have been observed in toxicity studies. Wildlife-protective sediment concentrations for bioaccumulative COPECs were calculated with the same exposure dose equations that were used in the ERA. The otter (*Lutra canadensis*) and belted kingfisher (*Ceryle alcyon*) were selected as the model receptors due to their relatively large dietary exposures to sediment-associated chemicals that can bioaccumulate in biological tissue. Table B.7-5 presents the ecological PRGs for the selected sediment COPECs for each category of receptor considered in the ERA. The overall ecological PRG is the lower of the two values presented.

The toxicity data utilized in the residue-based analysis of fish tissue chemistry (*i.e.*, CBR) in the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] were selected as PRGs for fish tissue along with back-calculated values for fish tissue that are protective of wildlife. Rather than deriving PRGs for TCDD using the above approach, sediment concentrations protective of piscivorous mammals (2.5 picograms per gram or parts per trillion) and birds (21 picograms per gram) derived by the USEPA (1993a) were used to calculate fish

[5] Sediment PRGs for PAHs were only derived for the benthos because these compounds are not anticipated to bioaccumulate in the estuarine food web (as described in Appendix A of the FFS; Malcolm Pirnie, Inc., 2008a) to levels that would pose a threat to wildlife receptors.

tissue concentrations. The lower of these two calculated values was then selected as the wildlife PRG value for fish tissue. The fish tissue PRGs presented in Table B.7-3 include results of the residue-based (fish) and dose-based (wildlife) analyses conducted as part of the ERA.

Table B.7-5: Summary of Sediment PRGs for Ecological Receptors

Chemical	Units	Sediment PRGs		Lowest
		Benthos [1]	Wildlife [2]	
Inorganics				
Copper	ng/g	34,000	**13,318**	Wildlife PRG
Lead	ng/g	46,700	**10,606**	Wildlife PRG
Mercury	ng/g	150	**37**	Wildlife PRG
PAHs				
LMW PAHs	ng/g	**552**	-	NOAA ER-L
HMW PAHs	ng/g	**1700**	-	NOAA ER-L
PCB Aroclors				
Total PCBs	ng/g	**22.7**	365	NOAA ER-L
Pesticides/Herbicides				
Total DDx	ng/g	**1.58**	19	NOAA ER-L
Dieldrin	ng/g	**0.02**	271	NOAA ER-L
Dioxins/Furans				
TCDD TEQ [3]	ng/g	**0.0032**	0.0025	Wildlife PRG

Bolded values are those selected as ecological PRGs.
[1] Benthos PRGs are ER-L values from Long *et al.* (1995), except where noted.
[2] Derived as described in the FFS COPEC Screening Technical Memorandum [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].
[3] Benthic benchmark for 2,3,7,8-TCDD derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper (2003); wildlife value from USEPA (1993b).

Table B.7-6: Summary of Fish Tissue PRGs for Ecological Receptors

Chemical	Units	Fish Tissue PRGs		Lowest
		Fish [1]	Wildlife [2]	
Inorganics				
Copper	ng/g	**6.3**	21,935	Fish
Lead	ng/g	**88**	700	Fish
Mercury	ng/g	**19**	40	Fish
PAHs				
LMW PAHs	ng/g	**89**	-	Fish
HMW PAHs	ng/g	**89**	-	Fish
PCB Aroclors				

Chemical	Units	Fish Tissue PRGs		Lowest
		Fish [1]	Wildlife [2]	
Total PCBs	ng/g	**7.9**	676	Fish
Pesticides/Herbicides				
Total DDx	ng/g	**0.3**	147	Fish
Dieldrin	ng/g	**35**	487	Fish
Dioxins/Furans				
TCDD TEQ [3]	ng/g	0.050	**0.0007**	Wildlife

Bolded values are those selected as ecological PRGs.
[1] Based on critical body residuals as summarized in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].
[2] Derived as described in the FFS COPEC Screening Technical Memorandum [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]; lowest of mammal and avian values.
[3] Low risk fish concentrations for 2,3,7,8-TCDD from USEPA (1993a).

B.7.2.3 Preliminary Remediation Goals and Background

Another consideration in the development of long-term targets is the background contamination and its contribution to the residual risks. The background contaminant contributions to a site must be considered during PRG development to adequately understand contaminant sources and establish realistic risk reduction goals; thus, risks associated with background concentrations were estimated for human and ecological receptors and are discussed below. Investigation of sediment contaminant concentrations in the Upper Passaic River above the Dundee Dam revealed historic and ongoing upstream sources of metals, pesticides, PAHs and PCBs. The upstream concentrations of these contaminants are lower in comparison to their concentrations in the Lower Passaic River.

USEPA guidance defines “background” as levels of chemicals that are not influenced by releases from the site, including both anthropogenic and naturally derived constituents (USEPA, 2002d). The dam physically isolates the proximal Dundee Lake and other Upper Passaic River sediments from Lower Passaic River influences while the Lower Passaic River receives contaminant loads from above the dam. The proximity of these sediments to the proposed remediation area and demonstrated geochemical connection to a portion of the sediment contamination of the Lower Passaic River provide the rationale for considering the Upper Passaic River to represent reasonable background concentrations for the Lower Passaic River for the purposes of this assessment. Because contaminant concentrations detected in sediment samples recently collected from the Upper Passaic River were found to be above the risk-based thresholds, the Upper Passaic River background concentrations were selected as PRGs.

In order to determine the cancer risks and noncancer health hazards associated with background sediment concentrations for an adult angler, biota tissue concentrations were estimated by multiplying the sediment background concentration by the chemical-specific BAF. Cancer risks and noncancer health hazards were calculated for ingestion of fish and crab assuming RME only for those contaminants in background sediment for which risk-based PRGs were developed (refer to Table B.7-2). The calculated cancer risks and noncancer health hazards for ingestion of crab are comparable to fish ingestion as a result of the slightly lower ingestion rate for crabs. A summary of the cancer risk and noncancer health hazards associated with the background concentrations are provided in Table B.7-7. The sediment background concentration for PCBs is the only concentration associated with cancer risks and noncancer health hazards that exceed the NCP criteria. The selection of the background concentration as opposed to risk-based PRGs emphasizes the need to investigate and remediate the area above the Dundee Dam to reduce this ongoing contribution to risks in the Lower Passaic River following an early remedy.

Table B.7-7. Summary of Cancer Risks and Noncancer Health Hazards Associated with Sediment Background Concentrations - Ingestion of Fish/Crab for an Adult Angler

Contaminant	Sediment Background Concentration (ng/g)	BAF [1]	Estimated Fish/Crab Tissue Concentration [2] (ng/g)	Cancer Risk [3]	Noncancer Health Hazard [3]
2,3,7,8-TCDD	0.0019	0.20	0.00038	$7x10^{-6}$	ND
Total PCB	460	2.2	1012	$2x10^{-4}$	18
Chlordane	23	20	451	$2x10^{-5}$	0.3

Mercury [4]	720	0.10	72	ND	0.3

ND – not determined because toxicity values are not available for this exposure route.

[1] Values obtained from Table 7-2 of the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

[2] Estimated tissue concentration derived by multiplying sediment background concentrations by the chemical-specific BAF.

[3] Cancer risks and noncancer health hazards were estimated assuming 40 eight-ounce fish or crab meals per year for 24 years. The methodology and RME-specific exposure assumptions are described in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

[4] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

Table B.7-8 presents the estimated risks associated with background conditions for each of the representative ecological receptors and endpoints used to quantify risks in the Lower Passaic River (as discussed in Section B.6.2.4 "Risk Characterization"). Risk estimates are presented as the geometric mean of the NOAEL- and LOAEL-based HQs, assuming that the geometric mean between the no-observable-effects and lowest-observable-effects reasonably represents the effects threshold. HQs for both benthic macroinvertebrates (based on sediment benchmarks and CBRs) and fish (CBRs) range from 0.00009 to 410, while those for the wildlife receptors (*e.g.*, mink and heron) are considerably lower, ranging from 0.007 to 3.4. The HQs for all COPECs except 2,3,7,8-TCDD (represented by the Total TCDD TEQ) exceeded 1.0 for at least one group of receptors. Background levels of all other COPECS may pose risk to benthic macroinvertebrates. Metals, PCBs and pesticides pose risks to both benthic macroinvertebrate and fish receptors. Piscivorous mammals, represented by the mink, may only be at risk from exposure to PCBs (HQ=3.4); and piscivorous birds are not at risk from exposure to background levels of any COPECs. Generally, risks to wildlife receptors from exposure to background concentrations of COPECs may be negligible based on the low HQs and highly conservative assumptions of exposure models.

Table B.7-8: Summary of Ecological Risk Estimates [1] for Representative Receptors at Background Conditions

Chemical Parameter	Background Concentration (ug/g)	Benthic Invertebrates/ Sediment Benchmarks	Benthic Invertebrates/ CBRs	Mummichog/ CBRs	AE/WP/ CBRs	Mink/ TRVs	Heron/ TRVs
Copper	63	**1.9**	**32**	**170**	**410**	0.21	0.08
Lead	130	**2.8**	0.11	**3.2**	**1.8**	0.13	0.30
Mercury	0.72	**4.8**	0.44	**2.8**	**23**	0.23	0.19
LPAHs	7.9	NA	NA	NA	NA	NA	NA
HPAHs	53	**31**	**2.4**	NA	0.20	0.11	NA
Total PCBs	0.46	**20**	**1.4**	**17**	**130**	**3.4**	0.19
Total DDx	0.030	**19**	**57**	0.026	**210**	0.0085	0.17
2,3,7,8-TCDD [3]	0.0000019	0.60	0.65	0.0009	0.0081	0.28	0.007
Total HI		**80**	**94**	**193**	**775**	**4.4**	0.94

Bolded values represent hazard quotients (HQs) that exceed 1.0.
NA – not available.
[1] Ecological risks associated with background conditions were estimated by multiplying the risk estimates for the Lower Passaic River by the ratio of the background concentrations to the EPCs presented in Table 2.6-6 through Table 2.6-11 in Section 2.6.2.4 "Risk Characterization" (*i.e.*, assuming that risks are a simple linear function of COPEC concentrations in sediment).
[2] Except for benthic invertebrates, all risk estimates are the geometric mean of the LOAEL- and NOAEL-based HQs.
[3] Value for 2,3,7,8-TCDD based on those for TCDD TEQ (Total); comparison assumes that only this compound contributed to the calculated TEQs for the Lower Passaic River.

As previously discussed, background concentrations were found to be higher than the lowest risk-based concentration thresholds and were therefore selected as the PRGs. Table B.7-7 lists the background concentrations of COPECs and COPCs, selected as the PRGs [Malcolm Pirnie, Inc. 2008 (anticipated)] for the Lower Passaic River.

Table B.7-9: Selected PRGs

Contaminant	Background Concentration (ng/g)
Copper	63,000
Lead	130,000
Mercury [1]	720
LMW PAHs	7,900
HMW PAHs	53,000
Total PCB	460
Total DDx	30
Chlordane	23
2,3,7,8-TCDD	0.0019

[1] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

The COPC and COPEC concentrations known to exist in surface sediments of the lower eight miles are much greater than the PRGs listed in Table B.7-9. For this reason, a remedial strategy that can reduce the concentrations to at least the level of background is necessary to begin to achieve the RAOs. The lower eight miles have been identified as a major source of contamination to the Lower Passaic River [Malcolm Pirnie, Inc. 2008 (anticipated)], and it has been determined that the remediation of this area (through the Source Control Early Action) would be capable of achieving acceptable risk reduction [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action is necessary above Dundee Dam to identify and reduce or eliminate upstream sources of contaminants to the river. Future actions might include identifying facilities above the dam with on-going contributions to the Upper Passaic River or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or New Jersey state regulatory programs.

B.7.3 Evaluation of Future Risks: How RAOs and PRGs Address Risks Identified in the Risk Assessment

B.7.3.1 Evaluation of Future Human Health Risks

Future risks in the absence of remediation were evaluated considering the declining concentrations of PCBs and dioxins based on historical data. The analysis used a model that calculated the decreases in concentrations of COPCs in sediments and corresponding decreases in concentrations of COPCs in fish tissue. The calculated concentrations provide a means of comparing natural recovery (no action) to the active remedial alternatives.

An examination of risks to human health in the absence of remedial action in the HHRA for the FFS [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] concluded that both current and projected future concentrations of COPCs in fish and crab are above acceptable levels that are protective of human health. Consistent with the NCP, the evaluations also assumed no institutional controls, such as the current fish consumption advisories, because institutional controls are designed to control exposure and are considered to be limited action alternatives. Dioxins and PCBs are the primary risk drivers.

Building on the information from the HHRA, a future risk assessment was performed to compare the reductions in risk for natural recovery (no action) and active remedial alternatives. The results of the future risk assessment will be used to assist risk management decisions regarding the selection of a remedial alternative. Potential future risks to human health were calculated for three remediation scenarios:

- Natural Recovery (No Action)
- Active Remediation of the Primary Erosional Zone and/or the Primary Inventory Zone (PEZ/PIZ)
- Active Remediation of the Area of Focus

The future risk evaluation (presented in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] used the same set of COPCs and the same risk assessment methodology, including potential exposure scenarios and assumptions, that were evaluated in the current risk evaluation.

Future chemical concentrations in fish and crab were estimated using projected sediment concentrations determined from an empirical mass balance (EMB) for the system and BAFs. A description of the empirical mass balance approach used to estimate surface sediment concentrations is provided in the EMB [Appendix D of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Several sets of future EPCs were developed for each of the COPCs, corresponding to each of the remediation scenarios (*i.e.*, remediation of the PEZ/PIZ; remediation of the Area of Focus; and Natural Recovery (No Action) at two time periods. The first time period was selected to represent the year remediation is expected to be complete (*i.e.*, 2018). Predicted average concentrations at 2018 are used to represent concentrations for the time and are indicative of the affect the remedy has on reducing concentrations. The second time period evaluated is at 2048, 30 years following remediation. To derive EPCs to estimate future cancer risks and noncancer health hazards, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years. This 30-year average concentration is used to represent a concentration that is contacted over the exposure period.

Results from the current risk evaluation were used as a baseline to assess the relative risk reduction afforded by the Natural Recovery (No Action) alternative, active remediation of the PEZ/PIZ, and active remediation of the Area of Focus. Table B.7-10 presents a summary of the future risk/hazard for each alternative, along with a comparison of the relative reduction in risk/hazard with baseline conditions.

Table B.7-10: Summary of Baseline and Future Cancer Risk and Noncancer Health Hazards and the Relative Reductions in Risk/Hazard after 30 Years

Fish Consumption	Time Period [1]	Adult + Child Combined Risk	Adult Hazard	Child Hazard	Relative Reduction [2]		
					Combined Risk	Adult Hazard	Child Hazard
Natural Recovery (No Action) [3]	2018	$5x10^{-3}$	55	86	47%	13%	13%
	2019-2048	$4x10^{-3}$	44	68	60%	32%	31%
Active Remediation of Primary Erosional Zone/Primary Inventory Zone	2018	$3x10^{-3}$	31	48	70%	52%	51%
	2019-2048	$3x10^{-3}$	29	46	75%	54%	54%
Active Remediation of Area of Focus	2018	$5x10^{-7}$	$8x10^{-6}$	$1x10^{-5}$	100%	100%	100%
	2019-2048	$6x10^{-4}$	11	17	94%	83%	83%
Baseline [4]		$1x10^{-2}$	64	99			
Crab Consumption	**Time Period [1]**	**Adult + Child Combined Risk**	**Adult Hazard**	**Child Hazard**	**Relative Reduction [2]**		
					Combined Risk	**Adult Hazard**	**Child Hazard**
No Action Alternative	2018	$5x10^{-3}$	47	77	77%	45%	45%
	2019-2048	$4x10^{-3}$	37	60	82%	57%	57%
Active Remediation of Primary Erosional Zone/Primary Inventory Zone	2018	$3x10^{-3}$	26	43	87%	69%	69%
	2019-2048	$2x10^{-3}$	25	41	89%	71%	71%
Active	2018	$6x10^{-7}$	$4x10^{-6}$	$7x10^{-6}$	100%	100%	100%

Remediation of Area of Focus	2019-2048	$5x10^{-4}$	9	15	97%	89%	89%
Baseline [4]		$2x10^{-2}$	86	140			

The approach used to estimate risk/hazard for human receptors is provided in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].
[1] The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 are used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years *(i.e.*, 6 years as a child and 24 years as an adult).
[2] Baseline conditions compared to estimated future conditions.
[3] Detailed discussions of the remedial alternatives are provided in Section 2.8 "Description of Remedial Alternatives."
[4] The current scenario is assumed to represent the risks in 2007, before remediation is initiated and prior to accounting for natural degradation (*e.g.*, monitored natural recovery). Current risk represents the RME.

While the proposed remedies will effectively reduce human health risks, they will not be reduced to acceptable levels because of contaminant sources in the Upper Passaic River above Dundee Dam. Because of these sources, risks will never fall below 10^{-4} cancer risks (1 in 10,000) from fish consumption. As a consequence, fish consumption advisories will remain in place until future source track-down programs identify and reduce or eliminate upstream sources of contaminants.

B.7.3.2 Evaluation of Future Ecological Risks

The future ecological risk evaluation (also presented in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] used the same set of COPECs, exposure factors, and toxicity benchmarks that were used to assess current ecological risks to evaluate potential future hazards associated with each remedial alternative being considered. Results from the assessment of current conditions were then used to evaluate the relative reduction in hazards associated with each alternative to aid in decision-making. Consistent with the assessment of current conditions, three broad ecological receptor categories were evaluated: macroinvertebrates, fish, and aquatic-feeding wildlife.

Ecological risks were estimated for two future time points: immediately following the completion of the remedy (anticipated for the year 2018) and 30 years thereafter (year.2048). When possible, the risk estimates are bounded by presenting both on NOAEL- and LOAEL-based calculations.

As was done for the human health assessment, the predicted future chemical concentrations in sediment were estimated from the EMB model using current sediment data and modeled to fish and crab tissue using BAFs. A description of the empirical mass balance approach used to estimate surface sediment concentrations is provided in the EMB [Appendix D of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. An explanation of the application of BAFs is provided in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. The summaries of estimated future risks for each receptor are provided in Table C-1 through Table C-6 in Appendix C of this document "Supporting Tables for Estimates of Future Hazards for Ecological Receptors."

In summary, twelve sets of future EPCs were developed for each COPEC, corresponding to each of the three remediation scenarios at two time periods (*i.e.,* 2018 and 2048) for both the entire lower eight miles of the river and the mudflats alone. Table B.7-9 presents a summary of the geometric mean of the NOAEL and LOAEL HI calculated for the evaluated receptors for current conditions and for each of the three selected remedial scenarios. Typically, a HI equal to the sum of the HQs is only used when the contaminants of concern cause effects by the same mechanism and those effects are additive. For this evaluation, HIs are used to simplify risk estimates for comparison to determine whether there are differences in overall risk between scenarios. The geometric mean is used here to present the risk based on a single effect level.

The assessment of risk under current conditions strongly supports the conclusion that ecological receptors that reside in the river are adversely impacted as a result of exposure to COPECs associated with the river sediment and biological tissue. A similar evaluation of future remedial scenarios indicates that active remediation of the Area of Focus will result in the greatest reduction in ecological hazards, and ecological improvements are predicted to occur in a substantially shorter period of time. None of the remedial scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, it is anticipated that active remediation of the Area of Focus would result in a reduction in risk to wildlife receptors of 93 to 95 percent by the year 2048. Separate source control actions above Dundee Dam, when implemented, will accelerate the time frame within which the active remedial alternatives for the Area of Focus will reach the condition of no significant risk of harm for the ecological receptors.

Table B.7-11: Summary of Ecological Hazards Associated with Current Conditions and Various Remedial Scenarios

Receptor/ Endpoint	Remedial Scenario [a]	Baseline Hazard [b]	Estimated Future Hazard [b]		Hazard Reduction [c]
			2018	2048	
Macroinvertebrates/sediment benchmarks					
	No Action	1,900	376	227	88%
	Primary Erosional Zone/Primary Inventory Zone		210	164	91%
	Area of Focus		0.063	73	96%
Macroinvertebrates/CBRs [d]					
	No Action	1,670	544	330	80%
	Primary Erosional Zone/Primary Inventory Zone		303	241	86%
	Area of Focus		0.505	112	93%
Fish (AE/WP)/CBRs					
	No Action	6,860	2,545	1,780	74%
	Primary Erosional Zone/Primary Inventory Zone		1,420	1,370	80%
	Area of Focus		0.006	818	88%
Fish (mummichog)/CBRs					
	No Action	694	440	353	49%
	Primary Erosional Zone/Primary Inventory Zone		247	277	60%

	Area of Focus		0.0004	198	71%
Mammal (mink)/ingestion dose modeling					
	No Action	341	2	8	74%
	Primary Erosional Zone/Primary Inventory Zone		6	60	82%
	Area of Focus		0.015	21	94%
Bird (heron)/ingestion dose modeling					
	No Action	24	7.2	4.4	82%
	Primary Erosional Zone/Primary Inventory Zone		4.1	3.2	87%
	Area of Focus		0.017	1.8	92%

[a] A detailed discussion of the remedial alternatives is provided in Section 2.8 "Description of Remedial Alternatives."

[b] The approach used to estimate ecological hazards is provided in the Risk Assessment [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. Where bounding estimates of the hazards were derived, the geometric mean of the upper and lower bounds are provided above.

[c] Compared to baseline conditions after 30 years.

[d] CBR are threshold tissue concentrations above which adverse effects have been reported in the literature.

The following general conclusions are drawn from the risk assessment:

- In all instances, the Area of Focus remediation scenario would result in the greatest reduction in ecological hazards. Furthermore, ecological risk reduction is predicted to occur in a substantially shorter period of time. Ecological risks associated with active remediation of the Area of Focus are estimated to be two to four times lower than those associated with the No Action scenario.

- None of the remediation scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, by the year 2048, it is anticipated that wildlife receptors would have a hazard reduction of 93 to 94 percent (based on the geometric mean) for the Area of Focus remediation scenario. Further reduction of COPEC concentrations to achieve acceptable risk levels would require a source track-down program to identify and reduce or eliminate continuing contaminant sources in the Upper Passaic River above Dundee Dam.

B.7.3.3 Estimated Time to Achieve Risk-Based PRGs and Interim PRGs

The PRGs (obtained from Tables B.7-2 and B.7-9) were compared with forecasted future sediment concentrations to determine the number of years it would take for sediment concentrations to achieve the PRG values. Future forecasted concentrations are provided in Appendix D of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]. For human health, the estimated number of years after remediation has been completed to achieve the PRGs and interim PRGs for the primary contributors to excess cancer risk and noncancer hazard are summarized in Table B.7-12 for each of the remedial alternatives. Sediment and tissue COPC concentrations were projected up to 60 years after remediation is completed based on the limitations of the EMB model (surface sediment concentrations past 2075 cannot accurately be forecasted).

predecisional -deliberative

For total PCBs, the EMB predicts that it will take more than 60 years after remediation to achieve the PRG for all three remedial alternatives. However, interim human health PRGs for active remediation of the Area of Focus are predicted to be achieved in a much shorter period of time. Active remediation of the Area of Focus will achieve interim sediment PRGs for ingestion rates of 2 meals per year ($1x10^{-4}$ risk level and HQ of 1) and 1 meal per year ($1x10^{-5}$ risk level and HQ of 1) immediately after remediation is completed.

Commented [FB22]: Not sure I like this formulation

The EMB predicts that it will take more than 60 years after remediation to achieve the sediment PRG for dioxin for all three remedial alternatives. However, interim human health PRGs following active remediation of the Area of Focus are predicted to be achieved in a much shorter period of time. Active remediation of the area of focus will achieve interim sediment PRGs for ingestion rates of 12 meals per year ($1x10^{-4}$ risk

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level), and 2 meals per year ($1x10^{-5}$ risk level) are achieved immediately after remediation is completed.

As mentioned previously, these interim PRGs may be used to provide concentrations for fish advisories that may be established as an institutional control for part of the Source Control Early Action. Any advisories may be relaxed over time as sediment concentrations, fish body burdens, and human health risks are reduced.

Table B.7-12. Comparison of Alternatives - Years to Achieve PRGs and Human Health Interim PRGs

			Number of Years After Remediation is Complete for Interim Human Health PRGs[2] to be Achieved											
			12 Meals/Year				2 Meals/Year				1 Meal/Year			
COPC	**Alternative**	**Number of Years to Achieve PRG[1]**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HQ=1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HQ=1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HQ=1**
Total PCBs	Natural Recovery (No Action)	>60	>60	>60	>60	>60	>60	>60	0	>60	>60	44	0	20
	Active Remediation of Primary Erosional Zone/Primary Inventory Zone	>60	>60	>60	45	>60	>60	>60	0	>60	>60	17	0	0
	Active Remediation of Area of Focus	>60	>60	>60	0	>60	>60	>60	0	0	>60	0	0	0
TCDD TEQ (D/F)	No Action Alternative	>60	>60	>60	>60	NA	>60	>60	0	NA	>60	>60	0	NA
	Active Remediation of Primary Erosional Zone/Primary Inventory Zone	>60	>60	>60	>60	NA	>60	>60	0	NA	>60	52	0	NA
	Active Remediation of Area of Focus	>60	>60	>60	0	NA	>60	0	0	NA	>60	0	0	NA

NA – not applicable; No toxicity values are available at this time to derive a PRG.
[1] The PRG selected is the background value listed in Table 2.7-7.
[2] Interim human health PRGs summarized in Table 2.7-4.

The estimated number of years after remediation has been completed to achieve the PRGs and ecological risk-based PRGs for COPECs are summarized in Table B.7-13 for each of the remedial alternatives. Sediment COPEC concentrations were projected up to 60 years after remediation is completed based on the limitations of the EMB model (surface sediment concentrations past 2075 cannot accurately be forecasted).

predecisional -deliberative

Concentrations of PAHs are already below the PRG and are expected to remain below these concentrations. However, they will continue to remain at concentrations that present risk to ecological receptors, regardless of remedy or time. Active remediation of the Area of Focus will also achieve the PRG immediately after remediation is completed; but, again, concentrations will continue to remain at levels that present risk to ecological receptors. It will take more than 60 years to achieve PRGs for all other COPECs, regardless of the remedy. It is important to note that active remediation of the Area of Focus will immediately achieve PRGs for the lower eight miles of the Passaic River for all COPECs. However, recontamination of the lower eight miles from other external sources may cause contaminant concentrations to rise above PRGs after a period of time.

Based on the models, only risk-based PRGs for copper and dioxin will be achieved and maintained. For all other COPECS, only background concentrations can be expected to be achieved. This results in a significant reduction in risks to ecological receptors, but not complete elimination.

Table B.7-13. Comparison of Alternatives - Years to Achieve and Maintain Background and Ecological Risk-Based PRGs

Contaminant	Remedial Alternative	Years to Achieve Background	Years to Achieve Benthos PRG	Years to Achieve Wildlife PRG
Copper	No Action	>60	>60	>60
	Primary Erosional Zone/Primary Inventory Zone	>60	>60	>60
	Area of Focus	>60	>60	>60
Lead	No Action	>60	NA	NA
	Primary Erosional Zone/Primary Inventory Zone	>60	NA	NA
	Area of Focus	0	NA	NA
Mercury [1]	No Action	>60	NA	NA
	Primary Erosional Zone/Primary Inventory Zone	>60	NA	NA
	Area of Focus	>60	NA	NA
LMW PAHs	No Action	-	-	-
	Primary Erosional Zone/Primary Inventory Zone	-	-	-
	Area of Focus	-	-	-
HMW PAHs	No Action	0	NA	NA
	Primary Erosional Zone/Primary Inventory Zone	0	NA	NA
	Area of Focus	0	NA	NA
Total PCB	No Action	>60	NA	
	Primary Erosional Zone/Primary Inventory Zone	>60	NA	NA
	Area of Focus	>60	NA	NA
Total DDx	No Action	>60	NA	NA
	Primary Erosional Zone/Primary Inventory Zone	>60	NA	NA
	Area of Focus	>60	NA	NA
2,3,7,8-TCDD	No Action	>60	>60	>60
	Primary Erosional Zone/Primary Inventory Zone	>60	>60	>60
	Area of Focus	>60	58	>60

NA = Not achieved in a predictable or reasonable timeframe.
[1] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

B.8 DESCRIPTION OF REMEDIAL ALTERNATIVES

In addition to the No Action alternative (Alternative 1), nine active remedial alternatives are being evaluated for the FFS and are detailed in Figures B.8-1, B.8-2, and B.8-3. The active remedial alternatives target the fine-grained sediment present in the lower eight miles by dredging, capping, or a combination of these options.

Dredging Alternatives

There are three dredging alternatives that involve mechanical dredging[6] to remove fine-grained sediment from the lower eight miles of the river. These dredging alternatives differ in their DMM options:

- Alternative 2 – Dredging with Confined Disposal Facility (CDF) Disposal
- Alternative 3 – Dredging with Off-site Treatment and Disposal
- Alternative 4 – Dredging with Decontamination and Beneficial Use

The Lower Passaic River contains a federally-authorized navigation channel. In RM0 to RM7, it is 300 feet wide and ranges in depth from 30 feet MLW to 16 feet MLW. In RM7 to RM8, it is 200 feet wide and 16 feet (MLW) deep. Within the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment corresponds well with the depth of historical dredging. For this reason, the depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The resulting sediment removal depth would be 33 feet MLW for RM0.0 to RM2.5, 23 feet MLW for RM2.5 to RM4.6, 19 feet MLW for RM4.6 to RM7.1, 19 feet MLW for RM7.1 to RM8.1, and 13 feet MLW for

[6] Mechanical dredging is the representative process option used for cost estimating purposes. Hydraulic dredging was not eliminated from consideration.

RM8.1 to RM8.3. Dredging slopes would be constrained to a slope of approximately 3 horizontal to 1 vertical (3H:1V).

Outside of the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment varies. Therefore, data from geotechnical cores and chemical cores were used to estimate the depth of the fine-grained sediment boundary at various locations in the river. The depth of dredging at each of these locations is the estimated depth of fine-grained sediment plus an additional one foot to account for dredging accuracy.

The objective of the dredging alternatives is to remove as much of the fine-grained sediment as practicable, resulting in the exposure of the underlying sandy material. As soon as practicable after exposure of this sandy material, a nominal two feet of sandy backfill material would be placed to mitigate dredging residuals. Unlike a cap, this backfill material would not be maintained following installation.

The dredged material removed during implementation of Alternative 2 would be placed into one or more nearshore CDFs. The CDF may include an underlying sub-grade cell[7] for additional capacity. After the material is passively dewatered, it would be permanently capped in place. Best management practices and engineering controls, including treatment of any supernatant water discharges, would be implemented.

The dredged material removed during implementation of Alternative 3 would be dewatered at a local upland sediment processing facility and stabilized as necessary. The dredged material would then be transported via truck, barge, and/or rail off-site for thermal treatment and final disposal.

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[7] A sub-grade cell is an excavation beneath and within the footprint of the CDF to a predetermined depth, constructed to create additional capacity.

The dredged material removed during implementation of Alternative 4 would be dewatered, conditioned as necessary, and treated by an onsite or regional thermal treatment facility (decontamination plant). The decontaminated dredged material would be beneficially used if applicable.

After construction is completed, these alternatives rely on institutional controls, such as fish consumption advisories, while natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives (RAOs) are achieved. A long-term monitoring program would be implemented to verify that the river is responding with reduced contamination levels over the long term. A review of site conditions would be conducted at five-year intervals, as required under CERCLA.

Capping Alternatives

There are six capping alternatives (Alternatives 5 through 10) that would sequester the contaminated sediments in the lower eight miles under an engineered cap. Placing a cap over the existing river bathymetry would result in considerable flooding increases. Therefore, pre-dredging prior to cap placement has been incorporated into all the capping alternatives where needed to prevent additional flooding. Dredging depths would be configured in such a way that no net increase in the acreage flooded under the base case (100 year flood based on 2004 bathymetry) is shown with flood modeling. As with the dredging alternatives, the capping alternatives consider a variety of DMM options. The capping alternatives are as follows:

- Alternative 5 – Capping with CDF Disposal
- Alternative 6 – Capping with Off-site Treatment and Disposal
- Alternative 7 – Capping with Decontamination and Beneficial Use
- Alternative 8 – Capping with Navigation and CDF Disposal
- Alternative 9 – Capping with Navigation and Off-site Treatment and Disposal
- Alternative 10 – Capping with Navigation and Decontamination and Beneficial Use

Three of the capping alternatives (Alternatives 8 through 10) incorporate navigation requirements for the reasonably anticipated future use of the river. The USEPA has evaluated the information pertaining to navigation of the river [Appendix F of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and has determined that the navigation requirements for the reasonably anticipated future use of the lower eight miles of the river are as follows:

- Channel depth of 30 feet below MLW from RM0 to RM1.2. At RM1.2 the river is constrained by bridge abutments of a formerly utilized railroad freight bridge. These abutments limit channel width to 145 feet.
- Channel depth of 16 feet below MLW from RM1.2 to RM1.9. At RM1.9 navigation would be constrained by the United States Route 1 (Pulaski Skyway) Bridge, which is a fixed span bridge (*i.e.*, a bridge that does not open).

Alternatives 8 through 10 include a navigation channel from RM0 to RM1.9 to support the reasonably anticipated future navigation use (*i.e*., depth of 30 feet at MLW from RM0 – RM1.2 and depth of 16 feet at MLW from RM1.2 to RM1.9). From RM0-1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (30 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The channel sides would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine-grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following installation.

From RM1.2 to RM1.9, the currently authorized and constructed channel extends to a depth of 30 feet MLW. To configure a 16 foot deep channel, dredging would occur to the depth required to accommodate navigation (16 feet) plus the depth to accommodate future navigation channel maintenance, the thickness of the cap, and dredging accuracy (an additional 5.5 feet for the combination of these three additional components, for a total dredging depth of 21.5 feet).

In the sideslope and shoal areas of RM0 to RM1.9, and from RM1.9 to RM8.3, it is likely that additional, un-targeted contaminant inventory would remain in place. Therefore, an engineered sand cap would be placed in these areas. In areas of unacceptable erosion, as identified with cap erosion and flood modeling, stone would be used as armor material. In select, small areas of the river, existing mudflats would be reconstructed by removing 3 feet of contaminated sediment, placing 1.5 feet of sand as capping material, and placing 1 foot of mudflat reconstruction (habitat) substrate.

It has been assumed that placement of sand material would be conducted using conventional methods, which would be capable of minimizing the amount of settlement of the sand material into the existing silt. Placement of armor material would be achieved using mechanical methods, typically from water-borne vessels. Due to the proximity to shore, mudflat reconstruction material would likely be placed via shore-based mechanical equipment.

The dredged material removed during the implementation of Alternatives 5 through 10 would be managed as described above for the corresponding Alternatives 2 through 4.

After construction is completed, capping Alternatives 5 through 10 rely on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while natural recovery processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term Post-Construction Monitoring Program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

B.8.1 Compliance of Monitored Natural Recovery with USEPA Policy

The MNR component of the active alternatives was developed in accordance with *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005c). A detailed understanding of the natural processes that are affecting sediment and contaminants at the site was developed in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c), and a tool to predict future effects of these natural processes was developed in the EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. The ongoing flux of background contaminant loads over Dundee Dam has been discussed in the CSM, and the USEPA plans to initiate a track down program to identify and characterize sources of contamination above Dundee Dam [Malcolm Pirnie, Inc. 2008 (anticipated)]). A detailed HHRA and ERA have been performed [Appendix C of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] to address ongoing risks and exposure control. Monitoring of natural processes and contaminant concentrations to assess natural recovery can be performed through sediment and biological tissue sampling programs.

The reduction of contaminant concentrations through MNR in the Lower Passaic River will rely on two major processes:

- Burial and/or mixing-in-place of contaminated sediment with cleaner sediment.

- Dispersion of particle-bound contaminants or diffusive or advective transport of contaminants to the water column.

Contaminant reduction through transformation processes (*e.g.*, biodegradation, abiotic transformations) and sorption or other binding processes will not be relied upon.

B.9 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Nine criteria are used to address the CERCLA requirements for analysis of remedial alternatives. The first two criteria (overall protection of human health and the environment, and compliance with ARARs) are threshold criteria that must be met by each alternative. The next five criteria (long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, short-term effectiveness, implementability, and cost) are the primary balancing criteria upon which the analysis is based. The final two criteria, referred to as modifying criteria, are typically applied following the public comment period for the Proposed Plan to evaluate state and community acceptance. The following sections present a detailed analysis of the individual remedial alternatives in reference to the evaluation criteria and a comparative analysis to evaluate the relative performance of remedial alternatives in relation to each evaluation criterion. The comparative analysis of remedial alternatives is summarized in Table B.9-1 (a summary of the detailed analysis) and Table B.9-2 (a summary of quantitative estimates for each alternative).

B.9.1 Overall Protection of Human Health and the Environment

Based on the risk evaluations summarized in Section B.6 "Summary of Site Risks," current conditions in the Lower Passaic River present risks to human health and the environment that exceed the USEPA risk range for cancer and noncancer health hazards. Alternative 1 is not protective under this criterion. Active remediation of the Area of Focus reduces the COPC and COPEC concentrations in the surface sediments to within the background concentrations that are currently introduced to the Lower Passaic River from the Upper Passaic River, reduces the human health risk by 94 to 97 percent (for fish and crab consumption, respectively), and reduces the ecological hazard by 71 to 96 percent (depending on the receptor). Based on prediction of future surface concentrations generated using the EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], active remediation of the Area of Focus followed by MNR will achieve all thresholds for 2,3,7,8-TCDD, which is responsible for about 65 percent of the current risk, approximately 40 years faster than they would be achieved by the No Action alternative. (Quantitative predictions presented are subject to the uncertainties in the EMB and Risk Assessment, as described in sections B.4.6.1, B.6.1.9, and B.6.2.5. However, inferences inherent in these evaluations have been derived from a thorough and comprehensive understanding of the site through the CSM, which was built upon detailed geochemical data evaluations and the assimilation of various data sources.) The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus. For this reason, the nine active alternatives are considered protective of human health and the environment.

B.9.2 Compliance with ARARs

Each active remedial alternative would be designed and constructed in compliance with the ARARs identified, except those which may be waived by the Regional Administrator in accordance with CERCLA Section 121(d).

The active remedial alternatives are comprised of up to eight elements, as listed below:

- Pre-Construction Activities
- Construction and Operation of a Support Area
- Dredging
- Capping
- CDF Construction and Operation
- Off-Site Treatment and Disposal
- Thermal Treatment
- Wastewater Treatment and Discharge

Table B.9-3 lists the ARARs and their statutory or regulatory citations for each of these eight elements. This table also presents the rationale for the parts of each element of the remediation process that will fall under each ARAR.

B.9.3 Long Term Effectiveness and Permanence

B.9.3.1 Magnitude of Residual Risk

The overall risk reduction achieved by each alternative has been evaluated based on the future surface concentrations predicted by the Empirical Mass Balance Model [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. Over the time frame considered (30 years after remedial actions are complete), the nine alternatives that use active remedial measures reduce cancer risk for the combined child/adult receptor from 1 x 10^{-2} to 6 × 10^{-4} from fish consumption and from 2 x 10^{-2} to 5 × 10^{-4} from crab consumption. In addition, the noncancer HI for the adult receptor is reduced from 64 to 11 from fish consumption and from 86 to 9 from crab consumption. The noncancer health HI for the child receptor is reduced from 99 to 17 from fish consumption and from 140 to 15 from crab consumption. The ecological hazards present at the site are reduced from 341 to 21 for the mink receptor and from 24 to 1.8 for the heron receptor [Malcolm Pirnie, Inc. 2008 (anticipated)]. The risk reduction for each of the nine active alternatives is equivalent at the level of precision achieved by the calculations presented in the EMB, and no additional risk reduction is estimated to result from additional removal of contaminated sediment, as each active remedial alternative places a sand layer and achieves equivalent surface concentrations following active remediation.

In addition, all of the active remedial alternatives rely on institutional controls to maintain protectiveness following remedy construction, while natural recovery processes continue to reduce surface concentrations in the Area of Focus and reduce risks and hazards to within the USEPA risk ranges. Existing fish consumption advisories will remain in effect and will be gradually relaxed according to risk thresholds as sediment and fish tissue concentrations improve over the long-term. Fish consumption advisories have definite limitations, however. Although fish consumption advisories are currently in place for the Lower Passaic River, creel surveys of anglers along the river have found that a considerable proportion of the group continues to consume fish and crab in spite of the “eat none” advisory; this consumption poses a risk to this population. As an institutional control, coordination between the NJDEP and USEPA regarding the issuance of fish consumption advisories will be necessary. Also, it may be necessary to implement outreach programs to inform the community regarding the advisories. In addition to fish consumption advisories, long-term institutional controls will include restrictions on dredging to create additional berths after the implementation of the Source Control Early Action, limitations on recreational use of the waterway, restrictions on private sediment disturbance activities, and dredging moratoriums.

The background contamination coming from the Upper Passaic River over Dundee Dam will be evaluated and addressed, if necessary, under a separate track down effort overseen by USEPA in cooperation with NJDEP. It is expected that this effort can be accomplished concurrently with the design and implementation of any remedial alternative for the Source Control Early Action, if selected. This track down effort, if implemented, will accelerate the time frame within which the active alternatives achieve risk ranges.

Alternative 1 does not achieve the reductions in risk described above for the active remedial alternatives. Over the time frame considered (30 years after the active components of remedial alternatives are complete), the natural recovery processes in Alternative 1 would only result in a reduction of cancer risk for the combined child/adult receptor to 4×10^{-3} from fish consumption and to 4×10^{-3} from crab consumption; these levels are still well above USEPA's risk range. In addition, the noncancer hazards (HI) for the adult receptor are reduced from 64 to 44 from fish consumption and from 86 to 37 from crab consumption. The noncancer hazards (HI) for the child receptor are reduced from 99 to 68 from fish consumption and from 140 to 60 from crab consumption. These reductions are substantially less than those achieved by remediation of the Area of Focus. The ecological hazards present at the site are reduced from 341 to 88 for the mink receptor and from 24 to 4.4 for the heron receptor. These reductions are less than for the active remedial alternatives as well. It should be noted that the risk reduction observed from Alternative 1 is due to natural recovery processes that are likely to include the dilution of contaminated sediments in the Area of Focus due to exchange with other contributing sources of solids load. This includes transfer of contaminated sediments from the Area of Focus to Newark Bay and the New York-New Jersey Harbor Estuary. It should also be noted that dilution of contaminated sediments in the Lower Passaic River under Alternative 1 does not take into account other remediation activities that may occur in other portions of the Harbor; remediation of sediments that enter the Lower Passaic River from other portions of the Harbor would enhance this dilution mechanism.

B.9.3.2 Adequacy and Reliability of Controls

Alternative 1 does not provide for engineering controls on the river sediments. Among the active remedial alternatives, there is not a great difference in the degree of adequacy of controls achieved. The reliability of both dredging (contaminant removal) and engineered caps (contaminant containment) depends upon proper design and implementation, while the reliability of capping also depends on the consistency and sufficiency of future maintenance, which would be required in perpetuity.

Alternatives 2 through 4 rely exclusively on placement of a backfill layer to provide a measure of control in the event that residual contamination poses health risks. These alternatives do not include an engineered cap, because the intent is for the contaminated fine-grained sediment to be permanently removed with the assumption that the underlying less-contaminated sand material will not erode to any significant extent. The backfill layer is not intended to be maintained, in contrast to the engineered cap in Alternatives 5 through 7, whose thickness is maintained in perpetuity in order to ensure protectiveness of contaminant inventory left underneath. Alternatives 8 through 10 rely on a combination of backfill and engineered cap, the quantities and placement locations of which are identical for these three alternatives and are dependent upon navigation requirements and the amount of contaminated inventory remaining after dredging in different portions of the Area of Focus. Institutional controls would be required to prevent disturbance of engineered cap layers by human activities. The conceptual design of the engineered cap and associated armor layer is based on the ability to withstand the modeled erosion susceptibility caused by a 100-year storm event [Appendices E and G of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

In Alternatives 2, 5, and 8, the use of a CDF for storage or final disposal, if constructed properly (*e.g.*, with low permeability barriers and with effluent controls), is considered to be adequate and reliable based on the characteristics of potential sites that have been preliminarily identified and the use of similar facilities in other projects.

Established thermal destruction facilities, which are incorporated into Alternatives 3, 6, and 9, have sufficient prior experience with treatment of hazardous materials, control of air emissions, and disposal of treatment residuals to predict a high level of reliability. Newly constructed facilities, incorporated into Alternatives 4, 7, and 10, would require a prove-out period to demonstrate ability to reduce contaminant concentrations to acceptable levels reliably and to ensure that air emissions are within acceptable ranges.

Water treatment processes associated with CDF effluent (in Alternatives 2, 5, and 8) and water resulting from sediment dewatering operations (in Alternatives 3, 4, 6, 7, 9, and 10) are considered to be adequate and reliable if constructed and maintained properly.

All active remedial alternatives include the use of long-term institutional controls, each of which has specific limitations. For instance, the implementation of fish consumption advisories along the Lower Passaic River may require community outreach programs to inform the community regarding the advisories. In addition, restrictions on dredging to create additional berth areas would need to be conducted such that resuspension of contaminated sediments in the berth area and subsequent recontamination of adjacent capped areas is minimized or avoided. Replacement of the engineered cap in the new berth area would also be required.

B.9.4 Reduction of Toxicity, Mobility, and Volume through Treatment

B.9.4.1 Treatment Processes Used and Materials Treated

Alternative 1 does not involve any containment or removal of contaminants from the Lower Passaic River sediments. Among the active remedial alternatives, the treatment processes used vary depending on the DMM option. Water treatment processes associated with CDF effluent (in Alternatives 2, 5, and 8) and water resulting from sediment dewatering operations (in Alternatives 3, 4, 6, 7, 9, and 10) will reduce the toxicity, mobility, and volume of contaminants present in the effluent or dewatering water. Use of the CDF itself (in Alternatives 2, 5, and 8) does not provide treatment of contaminated media. Thermal treatment of dredged sediment, incorporated into Alternatives 3, 4, 6, 7, 9, and 10, will irreversibly destroy organic contaminants in the treated sediment, while non-volatile metals will be fused and bound into the residual matrix (in the case of an on-site thermo-chemical treatment process) or into resultant incinerator ash which would be disposed of in accordance with facility permit requirements (for an off-site facility). Volatile metals will be released from the sediment matrix and captured during control of the off-gas emissions.

B.9.4.2 Amount of Hazardous Material Destroyed or Treated

Alternative 1 does not involve any destruction or treatment of contaminants from the Lower Passaic River sediments. Among the active remedial alternatives, the amount of contaminated sediment removed and treated varies based on the depth and extent of dredging and the associated removal of contaminant inventory. (The estimates of sediment removal volume are presented in Table B.9-2.) For example, Alternatives 2 through 4 remove the greatest amount of sediment, while Alternatives 5 through 7 remove the least. As such, Alternatives 2 through 4 involve destruction or treatment of the largest mass of contaminants, while Alternatives 5 through 7 involve treatment of the smallest mass. While Alternatives 3, 4, 6, 7, 9, and 10 involve treatment of contaminated sediments, Alternatives 2, 5, and 8 incorporate treatment of dewatering water only.

B.9.4.3 Degree of Expected Reductions in Toxicity, Mobility, and Volume

Alternative 1 results in minimal reduction in toxicity, mobility, and volume by natural recovery processes. It should be noted that any reductions observed for Alternative 1 are due to natural recovery processes, among which a dominant mechanism is likely the dilution of contaminated sediments in the Area of Focus due to exchange with other contributing sources of solids load. This dilution likely results in transfer of contaminated sediments from the Area of Focus to Newark Bay and the New York-New Jersey Harbor Estuary. As described earlier, it should be noted that other remediation activities that may occur in other portions of the Harbor would enhance this dilution mechanism.

The nine active remedial alternatives vary in their expected degrees of reduction in toxicity, mobility, and volume.

Alternatives 2 through 4 involve removal of all fine-grained sediment and are most consistent with the CERCLA statutory preference for permanence and removal.

Alternatives 5 through 10 rely on capping to sequester contaminated sediments. The cap reduces the mobility of contaminants because the solids-bound contaminants would be sequestered under an engineered cap, thus reducing the transport to Newark Bay and the New York-New Jersey Harbor Estuary and the availability and toxicity of contaminants to biota. Capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no appreciable reduction expected in the toxicity of contaminants nor will there be a reduction in volume of the contaminants beneath the cap.

Alternatives 5 through 10 involve some removal of contaminated sediments before placement of a cap and armor. Each of these alternatives would, to some degree, reduce the volume of contaminated sediment in the Lower Passaic River by removal. The degree of volume reduction varies based on the depth and extent of dredging. Alternatives 8 through 10 involve greater quantities of contaminated sediment removal prior to capping than Alternatives 5 through 7, resulting in a greater degree of volume removal and, therefore, reduction of long-term contaminant transport to Newark Bay and the New York-New Jersey Harbor Estuary and availability and toxicity to biota.

Treatment of contaminated sediment is incorporated into Alternatives 3, 4, 6, 7, 9, and 10. The type of treatment specified for the removed sediment dictates the degree of reductions in toxicity, mobility, and volume. Thermal treatment would be expected to achieve approximately 99.9999 percent reduction in organic contaminants. Thermal treatment residuals could be disposed in a secure landfill or CDF, or could be beneficially used (*e.g.*, converted to cement). Material disposed in a CDF (in Alternatives 2, 5, and 7) would not be treated prior to placement, but the mobility of the sediment, and thus of the solids-bound contaminants, would be reduced. Disposal in a CDF would not satisfy the CERCLA statutory preference for treatment. Disposal in a CDF would, however, facilitate the removal of contaminants from the environment and, therefore, the long-term transport to Newark Bay and the New York-New Jersey Harbor Estuary and the availability and toxicity of those contaminants to biota.

B.9.4.4 Type and Quantity of Residuals Remaining after Treatment

Alternative 1 generates no residuals. The active remedial alternatives vary in the quantity of residuals generated depending on the degree of sediment removal and the type of treatment employed.

All active remedial alternatives incorporate water treatment after sediment removal; as such, residuals such as flocculation sludge and filter sands would be generated. For Alternatives 2, 5, and 8, the quantities of these residuals would depend on the volume of sediment that would be removed and the associated volume of CDF effluent that would be treated. For Alternatives 3, 4, 6, 7, 9, and 10, the residuals quantities would depend on the sediment volumes that are removed and dewatered. In addition, alternatives involving sediment dewatering may generate debris such as rocks, wood, and a variety of navigational and urban refuse that would be unable to pass through the dewatering treatment train; these materials would need to be managed as waste or recycled. Debris generated during sediment removal in Alternatives 2, 5, and 8 may be disposed in the CDF. Thermal destruction (incorporated into Alternatives 3, 4, 6, 7, 9, and 10) would irreversibly destroy contaminants in the treated sediment. Thermal treatment residuals could be disposed in a secure landfill or CDF or be used beneficially as a product.

B.9.5 Short Term Effectiveness

No construction activities are associated with the remediation of sediments for Alternative 1, so it does not increase the potential for direct contact or ingestion of contaminants from the sediments beyond current levels. The active alternatives vary slightly in short term effectiveness, as discussed below. A detailed analysis of the anticipated short-term impacts associated with the alternatives was conducted for the FFS and is presented in Appendix E of that document [Malcolm Pirnie, Inc. 2008 (anticipated)]. The detailed analysis indicates that, aside from Alternative 1, Alternatives 5 and 8 are anticipated to have the lowest short-term impacts on the community, workers, and the environment due to the lower volume of sediment to be removed (compared to Alternatives 2, 3, and 4) and minimal amount of upland construction required (compared to other active remedial alternatives). Alternatives 3 and 4 are anticipated to have the greatest short-term impacts due to the larger volume of sediment to be removed (compared to Alternatives 5 through 10), the potential for increased traffic and vehicle exhaust associated with off-site transportation of dredged material (in Alternative 3), and the construction of large upland facilities for DMM (compared to Alternatives 2 through 4).

B.9.5.1 Protection of the Community during Remedial Actions

Implementation of any active remediation alternative would result in impacts to the community (*e.g.*, noise, lights, traffic, and odors) and could potentially require the processing, storage, transportation, and disposal of contaminated sediment near the Lower Passaic River. Engineering controls would be put in place to reduce the potential for exposure of the community to contaminants. The implementation of any remedial alternative would require the development of a Community Health and Safety Plan to ensure protection of the community during and after construction activities. Community outreach programs would be performed to understand the communities' health concerns during the project, and coordination with community members would be undertaken to identify actions needed to protect their health and safety. In addition, sampling during dredging and capping operations would be conducted that may be used to monitor the potential recontamination of the river.

Short-term impacts to the community via increases in traffic, accidents, odors, noise, lighting, impacts to air quality, and limitations on navigation and recreation vary among the active remedial alternatives depending on project duration and the amount of construction activities involved. Short-term impacts associated with alternatives that involve a larger quantity of sediment removal and, therefore, a longer project duration (*e.g.*, Alternatives 2 through 4) would impact the community for a longer period of time than alternatives involving less removal (*e.g.*, Alternatives 5 through 10). For example, short-term impacts associated with noise, lighting, and limitations on in-water recreation are anticipated to be greater for alternatives involving more dredge plants operating for a greater number of years.

Remedial alternatives also vary in the level of community protection that may be offered with respect to their associated DMM options. Alternatives involving CDF disposal (*i.e.*, Alternatives

2, 5, and 8) do not involve dewatering or treatment of contaminated sediments and, therefore, may offer more protection of local communities than alternatives involving off-site treatment and disposal (*i.e.*, Alternatives 3, 6, and 9) and decontamination (*i.e.*, Alternatives 4, 7, and 10). Specifically, air emissions associated with thermal treatment of dredged material must be permitted and monitored to ensure protection of the community, whether regional or off-site treatment is employed. Alternatives 4, 7, and 10, which incorporate the construction of a regional upland thermal treatment facility, are anticipated to be more visible and more disruptive to the community in the short term than active remedial alternatives in which the majority of construction is located in a near shore area, such as Alternatives 2, 5, and 8.

B.9.5.2 Protection of Workers during Remedial Action

The implementation of any active remediation alternative would potentially expose workers to contaminated sediment; however, dredging activities could result in a higher likelihood of exposure via direct contact, ingestion, and inhalation of contaminants in sediments and surface water than would placement of capping materials. The overall time during which workers would require protection is greater for alternatives which remove a greater volume of material. In addition, alternatives involving the construction of large upland processing facilities increase the potential for construction-related accidents than alternatives involving less upland construction. The implementation of any remedial alternative would require the development of a Worker Health and Safety Plan to ensure protection of workers during construction activities.

B.9.5.3 Environmental Impacts

Alternatives which involve dredging of larger quantities of material require longer project durations and potentially present incrementally greater potential for increased exposure of the community and biota to dredged material. This potential for exposure can be reduced with the proper engineering controls, health and safety approaches, and design considerations.

The short-term environmental impacts associated with resuspension of contaminated sediment, contaminant releases, and the generation of residuals is anticipated to be incrementally greater for alternatives involving greater volumes of sediment removal. Estimates of the mass of contaminant inventory that would be resuspended in association with Alternatives 5 through 10 have been calculated for the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]; estimates of resuspended inventory associated with Alternatives 2 through 4 are under preparation and not available for this package. It is estimated that approximately 0.075 kilograms and 0.12 kilograms of 2,3,7,8-TCDD would be resuspended in association with the capping and capping with navigation alternatives, respectively, which equate to an estimated annual release of approximately 0.014 kilograms and 0.023 kilograms, respectively. Resuspension and releases associated with cap placement or dredging activities could result in the transport of contaminated sediments and subsequent impacts to adjacent areas. The placement of cap materials would likely result in a lesser degree of contaminant resuspension and release than dredging of contaminated sediment (USEPA, 2005). As such, it is anticipated that alternatives targeting the removal of the entire contaminant inventory in the Area of Focus (*i.e.*, Alternatives 2 through 4) would involve the resuspension of the greatest quantity of contaminant mass and the highest level of contaminant releases and generated residuals.

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The existing habitat present in the Area of Focus would be impacted by any active remediation alternative due to physical habitat removal, smothering of biota, and transport of contaminated media (in the form of resuspension and releases) during dredging or capping activities. All active alternatives would involve the placement of clean material over existing sediment and reconstruction of mudflat areas impacted by remedial activities. In areas where armor is placed, benthic recolonization could occur, provided that silt or other benthic habitat material is subsequently deposited via natural processes. The construction of a CDF would constitute a permanent impact to habitat, and would require mitigation.

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B.9.5.4 Time until Remedial Action Objectives are Achieved

The nine active alternatives vary slightly in duration of implementation, as each alternative contains similar components including pre-design activities, design, mobilization, dredging, capping or backfilling, and demobilization. Following implementation, trends in surface sediment concentrations for each alternative are also comparable, as the post-implementation surface sediment concentrations achieved by each alternative are equivalent. These trends may be influenced by the depositional conditions achieved by each alternative.

Based on the relative contribution of the various sources of contamination considered in the EMB [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and historical trends in sediment cores, post-remediation COPC and COPEC concentrations were calculated for the various remedial alternatives, based on the fact that remediation will reduce the resuspension flux of legacy sediments. Sediment resuspension as a source will be controlled by active remediation because each remedial alternative includes the placement of sand material in the lower eight miles of the river. This sand material will restrict the erosion and mixing of older, more contaminated sediments with the Lower Passaic River surface sediment. By controlling resuspension, future surface sediment concentrations were calculated for natural recovery (no action), *i.e.*, no change in the resuspension source, and the active remedial alternatives. Refer to the EMB for further detail on these calculations [Appendix A of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)].

Given the natural processes that are occurring in the river, the concentrations of most COPCs and COPECs will decline over time regardless of the method chosen for remediation. However, the

EMB concluded that active remediation has a significant effect on how quickly the recovery will occur as compared to natural recovery processes alone.

The 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve PRGs through a fate, transport, and bioaccumulation model that is currently in development and not available for this package.

B.9.6 Implementability

B.9.6.1 Technical Feasibility

The No Action alternative (Alternative 1) and the active remedial alternatives (Alternatives 2 through 10) are all technically feasible.

An important consideration in evaluating the feasibility of each alternative after implementation is the impact on water surface elevation (and resulting impacts on flooding) caused by changes in the bathymetry and bottom roughness of the river. NJDOT requires that water surface elevations rise no more than 0.1 foot to minimize impacts on flooding. Alternative 1 would likely result in a gradual increase in water surface elevation due to continued accumulation of sediments; however this has not been confirmed by modeling. Hydrodynamic modeling results [presented in Appendix G of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] indicate that water surface elevations associated with Alternatives 5 through 7 would rise less than 0.1 foot, thereby complying with the NJDOT criterion. Alternatives 2 through 4 and 8 through 10 were not modeled, but are expected to result in water surface elevations similar to or less than those predicted by modeling of Alternatives 2 through 4, as similar sediment surface conditions but greater water depths are achieved by implementation of these alternatives.

The active remedial alternatives are also technically feasible with respect to the scale of the remediation. Although the scale of the project is large (the active remedial alternatives involve removing between 4.2 and 10.7 million cy of sediment and capping 650 acres), other large-scale dredging and capping projects exist that are comparable in scale, illustrating that the scope of the remedial alternatives is not unique among contaminated sediment projects. Approximately 2 to 4 million cy of dredged material are removed and managed annually in the New York-New Jersey Harbor (NJDOT-OMR, 2007). The Hudson River PCBs Superfund Site Phase 1 and Phase 2 dredging design currently includes the removal of approximately 1.8 million cy of sediment (Quantitative Environmental Analysis, LLC, 2007). A summary of sediment dredging at Superfund megasites is provided in "Sediment Dredging at Superfund Megasites: Assessing the Effectiveness" (National Research Council, 2007). The National Research Council report describes ideal conditions for dredging (*e.g.*, the presence of little debris, the ability to consistently overdredge into clean material); although not all of these ideal conditions may be present in the Lower Passaic River, there would be no exceptional challenge in the application of readily available environmental dredging techniques in the Lower Passaic River. With respect to large-scale capping projects, capping has been proposed for sites as large as 15 square nautical miles (*e.g.*, the Historical Area Remediation Site in New York Bight) and has been tested among numerous riverine systems (Georgia Institute of Technology Research Corporation, 2007).

Treatment technologies, including dredged material dewatering with geotextile tubes and various water treatment unit operations (incorporated into the remedial alternatives) are scalable to the large volumes of material anticipated for the Source Control Early Action. Thermal treatment of dredged material (incorporated in Alternatives 3, 4, 6, 7, 9, and 10) is a DMM option in which significant upscale is not technically feasible due to limitations on contaminant concentrations that can be released in air emissions. Storage of dredged material would be required for these alternatives to accommodate the allowable throughput of the thermal treatment process as dictated by air emission regulations.

B.9.6.2 Availability of Services and Materials

Alternative 1 does not involve the procurement of any services or materials; therefore, no implementability challenges are anticipated for this alternative.

Each active remedial alternative utilizes both dredging and capping or backfilling. Dredging and capping are both well developed technologies, and adequate, reliable, and available equipment and materials can be procured; there are no anticipated challenges to implementability.

Initial efforts have identified several potential land-based borrow sources in New Jersey collectively capable of supplying suitable capping material for the implementation of active alternatives; however, the capacity of individual sources has not been determined. Additionally, under the New York Harbor Deepening Program, several million cy of sand will be removed from federal navigation channels between 2008 and 2011; although modeling results [presented in Appendix G of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] show that a cap cannot be constructed of this sand alone, this sand could be suitable for use in a filter layer or as backfill material. Furthermore, substantial quantities of rock will be removed from federal navigation channels, and could, if processed, be used as armor material. Significant cost savings would be realized if remediation activities could be coordinated with regional dredging programs (*e.g.*, utilization of sand or rock from the Harbor Deepening Program) to beneficially use this dredged material for backfill of dredged areas or construction of an engineered cap.

A preliminary review of the environs of the Lower Passaic River and Newark Bay suggests there are various nearshore areas amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of Alternatives 2, 5, and 8. Thorough siting studies for a nearshore CDF as well as an upland processing facility (incorporated into all active remedial alternatives) would be required during the design phase. A detailed description of siting considerations to be taken into account during such studies has been prepared for the FFS [Appendix H of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] and is summarized in the following sections.

Alternatives 3, 4, 6, 7, 9, and 10 involve the treatment of contaminated sediment from the Lower Passaic River via thermal destruction methods. This feasibility analysis has identified potential thermal treatment options and vendors, and has identified no technical issues that would prevent construction of a new onsite facility. Existing treatment facilities have been identified that have sufficient storage and throughput capacity to handle the large volume of dredged material associated with these alternatives. A siting study for an onsite treatment facility (associated with the implementation of Alternatives 4, 7, and 10) would be required during the design phase to identify areas where sufficient storage and throughput capacity would be available. Initial efforts have identified two domestic and one international (*i.e.*, Canadian) thermal treatment facilities that are permitted to accept dioxin wastes [Appendix H of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)]. Waste such as non-contaminated debris that is determined not to require disposal at one of the above facilities may be disposed at an appropriate permitted facility, of which there are numerous in the proximity of the Area of Focus.

Air emission control technologies associated with thermal treatment of dredged materials are available and can be procured. Similarly, no anticipated challenges to implementability are anticipated for dewatering technologies (*e.g.*, geotextile tubes; associated with Alternatives 3, 4, 6, 7, 9, and 10) and water treatment technologies (incorporated into all active remedial alternatives).

B.9.6.3 Administrative and Logistical Feasibility

Administrative and logistical challenges associated with implementation of Alternative 1 are not anticipated because this alternative does not involve any remedial action or construction.

The execution of any active remedial alternative in the Lower Passaic River would require significant coordination with and among federal, state, and local agencies. Alternatives involving capping (*i.e.*, Alternatives 5 through10) would require that the creation of future habitat be discussed and that administrative procedures be adopted to maintain an engineered cap in perpetuity. Alternatives which incorporate greater quantities of sediment dredging (*i.e.*, Alternatives 2 through 4) could potentially require incrementally more coordination due to the greater impact that DMM activities would have on the surrounding area and, for Alternative 2, the need to identify suitable locations for a CDF for disposal of dredged material.

Administrative and logistical challenges associated with processing, treatment, and disposal facility siting would be present with the implementation of any active remedial alternative. Siting considerations for a nearshore CDF (incorporated in Alternatives 2, 5, and 8) and an upland processing facility (associated, to some extent, with all active remedial alternatives) are presented in Appendix H of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]. Major siting considerations involve identifying site locations with suitable characteristics and obtaining regulatory approvals and permits. Thorough siting studies will be required during the design phase.

Logistical issues associated with regional or off-site treatment and disposal of a large quantity of dredged material (particularly for Alternatives 2 through 4) would also need to be considered; an initial evaluation of transportation logistics is presented in Appendix H of the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]. Transport to an international (*i.e.*, Canadian) treatment or disposal facility may result in additional administrative challenges (compared to domestic treatment and disposal), such as permitting, ensuring compliance with international regulations, and handling public perceptions.

B.9.7 Cost

The total cost for each alternative has been estimated based on capital costs as well as O&M costs. The active alternatives range in cost from $0.9 billion to $7.0 billion [Malcolm Pirnie, Inc. 2008 (anticipated)].

B.9.7.1 Capital Costs

Capital costs have been estimated for activities pertaining to pre-construction investigations and design, mobilization/demobilization, site preparation, dredging and/or capping, monitoring activities, and DMM. While capital costs for these activities vary predictably based on the extent of remediation conducted, the major drivers of capital cost are dredging, capping, and DMM.

Alternatives which would remove the entire inventory of contaminated sediment in the Area of Focus (and therefore involve the largest dredging volume) are significantly more costly than alternatives which would utilize a combination of capping and pre-dredging (and therefore incorporate smaller volumes of sediment removal). For the capping alternatives, although capping costs are higher than dredging costs, the cost of dredging is still a significant part of the capital cost for these alternatives.

Capital costs are mostly influenced by the DMM scenario of a given alternative. Alternatives that utilize a CDF as means of final disposal are the most economical to construct. However, a CDF requires additional O&M, which other alternatives do not require. Alternatives that involve dewatering of the dredged sediment and off-site treatment and disposal are significantly more costly than other alternatives (*i.e.*, CDF disposal and on-site decontamination for beneficial use) due to costs associated with off-site transportation of the dredged material.

B.9.7.2 Operations and Maintenance Costs

Alternatives which employ an engineered cap over a greater area require more significant operations and maintenance costs. Monitoring of cap thickness and replenishment could be required in perpetuity. The extent of monitoring and maintenance, and therefore the total present worth of O&M costs, would depend on the time needed to verify the long term stability of the cap and the absence of significant contaminant fluxes through the cap. The cost estimates generated during this feasibility analysis have been based on a maintenance period of thirty years based on CERCLA guidance for conducting remedial investigations and feasibility studies (USEPA, 1988 and USEPA, 2000); however, a longer timeframe may apply for cap maintenance.Alternatives which involve CDF disposal require additional operations and maintenance costs for crust management and monitoring beyond the remedial alternative implementation period.

The total cost of alternatives is driven by the capital costs associated with DMM. Alternatives involving capping achieve the same risk reduction as alternatives involving greater quantities of dredging for significantly lower total cost; however, the reliability of capping depends on the consistency and sufficiency of future maintenance activities.

B.9.8 State Agency Acceptance

State acceptance is not addressed in this document, but will be addressed in the ROD. It is important to note that NJDOT is the WRDA non-federal sponsor, and NJDEP is a Trustee for the site; both are agency partners participating in the Study. As such, input from the State of New Jersey was sought and considered throughout the development of the FFS.

B.9.9 Community Acceptance

Community acceptance of the Source Control Early Action will be addressed in the ROD once public comments on the Proposed Plan have been received. Input from the public and interested stakeholders, including the partner agencies, was sought and considered throughout the development of the FFS. This occurred through various technical workgroup sessions organized and hosted by the USEPA, through publication of information on the project website (www.ourPassaic.org), publication of information to interested members of the public in the form of ListServ notices, and other community involvement activities. A meeting was held in July 2007 to brief the municipalities of the lower eight miles on the Source Control Early Action FFS. The towns of Kearny and Harrison, the City of Newark, and Hudson County participated in this meeting.

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B.10 PRINCIPAL THREAT WASTE

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. USEPA expects to use treatment to address the principal threats posed by a site, wherever practicable (USEPA, 1991). 1995 TSI coring data show that the highest concentrations (over 5 ppm) of 2,3,7,8-TCDD in the Lower Passaic River are found at RM 3.4, in the sediments adjacent to the Diamond Alkali plant at 80-120 Lister Avenue in Newark, NJ (see Figure B.10-1). predecisional -deliberative

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B.11 PREFERRED REMEDY

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B.12 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Chemical-specific, location-specific, and action-specific ARARs and "To Be Considered" Information (TBCs) are considered in the development and evaluation of remedial alternatives [Malcolm Pirnie, Inc. 2008 (anticipated)]. When an alternative is selected, it must be able to fulfill the requirements of all ARARs (or a waiver must be justified). The ARARs and TBCs presented in this section apply to all of the remedial alternatives.

Table B.9-3 provides a compilation of the ARARs identified for the FFS in consultation with the partner agencies, including statutory or regulatory citations for each ARAR. The ARARs are listed according to their applicability to each the seven elements of the Source Control Early Action (see Section B 9.2 "Compliance with ARARs").

No ARARs were identified as drivers for the remedial alternatives. ARARs drive the methods by which the remediation will be performed, but they do not drive the need for the remediation itself.

B.12.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs define concentration limits or other chemical levels for environmental media. This Early Action addresses the sediments of the lower eight miles of the Passaic River, as an operable unit of the larger Lower Passaic River Study Area (*i.e.*, the 17-mile, tidal portion of the river). The other portions of the Lower Passaic River Study Area, which include the sediments in RM8 to RM17 and the water column of the entire 17 miles, will be addressed as part of the RI/FS being conducted for the comprehensive CERCLA-WRDA study described in Chapter 1.3 (verify reference). Since the Early Action is intended to be consistent with any future remedial actions that might be proposed for the Lower Passaic River Study Area, it will contribute to the achievement of surface water ARARs that will be required in the comprehensive study. However, since compliance with surface water ARARs depends on an overall remedy for the 17-miles of the river, those ARARs will be addressed in the RI/FS for the Lower Passaic River Study Area. This Early Action addresses the sediments, so this Focused Feasibility Study evaluates achievement of RAOs, PRGs, ARARs and TBCs for the sediment.

A broad universe of potential chemical-specific TBCs was initially identified from criteria developed by other USEPA regions and a variety of other agencies [see FFS Appendix B "Sediment TBCs and Development of Preliminary Remediation Goals," Malcolm Pirnie, Inc. 2008 (anticipated)]. FFS Appendix B Table B-1 presents a detailed inventory of these potential TBCs and their sources, while Table B-2 lists the associated contaminant screening values. As described in FFS Section 2.4 "Development of Preliminary Remediation Goals," PRGs were developed for the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)]. These PRGs, while not ARARs, are concentration limits that have been developed specifically for the Source Control Early Action based on site-specific RBCs. They are thus considered to be more appropriate benchmarks for Early Action at the site than any of the initially identified chemical-specific TBCs. As a result, all of the potential chemical-specific TBCs were screened from consideration as viable criteria for the Early Action.

B.12.2 Location-Specific ARARs and TBCs

The location-specific ARARs and TBCs identified for the FFS are listed in Table 12-1

B.12.3 Action-Specific ARARs and TBCs

The action-specific ARARs and TBCs identified for the FFS are listed in Table 12-1

B.13 TECHNICAL AND POLICY ISSUES

Technical and policy issues associated with the selection and implementation of the Source Control Early Action are discussed below.

B.13.1 Dioxin Toxicity Values

Issues related to dioxin toxicity values are discussed in Section 2.6.1.2 "Types and Characteristics of Contaminants of Potential Concern."

B.13.2 Determining Future Navigational Requirements

The remedial alternatives presented in the FFS [Malcolm Pirnie, Inc. 2008 (anticipated)] incorporate varying levels of navigation in the lower eight miles of the Lower Passaic River. Alternative 1 does not change the existing navigation capacity in the river, but it limits the feasibility of future navigation channel maintenance. Alternatives 2 through 4 accommodate the federally authorized and constructed navigation channel depths (as described in Section B.5.2 "Surface Water Navigation Requirements"), which would be the deepest channel depths compared to those incorporated in the other alternatives. Alternatives 5 through 7 do not incorporate navigation in the lower eight miles and would require that the channel be de-authorized in this area. Alternatives 8 through 10 incorporate the reconstruction of the navigation channel to accommodate future use, as determined by the USEPA (Section B.5.2.2 “Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses”). Implementation of Alternatives 8 through 10 would require that the federally authorized navigation depth in RM1.2 to RM1.9 be changed and that the navigation channel be de-authorized in RM1.9 to RM8.3. De-authorization of the channel or a change in authorized depth would require approval by an act of Congress with concurrence by the State of New Jersey.

Determining which navigational use scenario will meet the needs of federal and state agencies as well as local governments and communities in the Study Area represents a policy issue with respect to the implementation of the Source Control Early Action. It is

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B.13.3 Siting of a CDF or Upland Processing Facility

Commented [B31]: I have made a stab at re-framing this section, but EPA should carefully review this to develop a section that is consistent with current understanding

The remedial alternatives presented in the FFS incorporate the use of a nearshore CDF or an upland processing facility (depending on the alternative) for the management of dredged materials. Siting considerations for each of these types of facilities are discussed below.

CDF Siting: The CDF would be used for passive dewatering of dredged sediment. Construction of a CDF would require containment measures such as double sheet-pile walls with bentonite fill. A leachate collection system would be constructed to control the migration of contaminants from the sediment, and effluent from the CDF would be treated prior to discharge. As a final use, the dewatered sediment in the CDF would be permanently capped. The anticipated future use of the capped CDF area would be commensurate with adjacent current land use; examples of anticipated future use include wetlands restoration, the creation of a beneficial use product such as a park, or light industrial development.

A preliminary screening analysis for potential nearshore CDF sites has been conducted [Appendix H of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)] to evaluate potential site locations. Extensive work has been performed to evaluate the feasibility of Site 7, an approximately 50-acre site located adjacent to the Toyota Motor Logistic Center, Inc. facility along the western shoreline of Newark Bay, directly north of the Port Newark channel. Site 7 was originally proposed for use as a CDF by New Jersey's Dredged Material Management Team and was designated as Site 2N and 2S. At the request of the Port Authority of New York and New Jersey, USACE issued an Environment Impact Statement (EIS) for the Newark Bay CDF site in April 1997 (USACE, 1997). The EIS indicated that generally short-term adverse impacts from construction of a CDF were balanced by potential beneficial impacts in this area, and that no long-term adverse impacts were expected. Based on this information, Site 7 has been assumed as the preferred location for construction of a nearshore CDF for Alternatives 5 and 8. Future site screening to supplement the preliminary siting study, including an analysis of geotechnical conditions and potential flooding impacts associated with the construction of a nearshore CDF, will be required to further evaluate potential sites and select the most appropriate site(s) for the development of a nearshore CDF for Alternatives 5 and 8.

Because of the significantly larger volume of material generated under Alternative 2 (refer to Table B.9.2 "Summary of Quantitative Estimates for Remedial Alternatives"), it is assumed that, for the purposes of generating cost estimates for Alternative 2, a larger site or a combination of sites would be required to accommodate the associated volume of dredged material. A combined footprint of approximately 100 acres has been assumed. For this alternative, an upland processing facility at which water treatment of the CDF effluent would occur would be constructed at a nearby location. As with Alternatives 5 and 8, future site screening will be required to supplement the preliminary siting study (USACE, 2006b and Appendix H "Dredge Material Management Assessments") and aid in the selection of a suitable CDF location or a combination of suitable locations for this alternative.

Technical issues related to the siting of a CDF include the following:

- The need for an extensive data collection program to identify and evaluate potential sites for the CDF; the program would include evaluations of site geology and potential flooding impacts, evaluations of local community needs, evaluation of the current land use at the potential CDF sites and adjacent properties, and other relevant analyses.

- The design and construction of the CDF, including containment measures.

Policy issues related to the siting of a CDF include the following:

- Willingness of the community to host such a facility.

- Determining preferences of local communities or agencies with a controlling interest in the selected area for the CDF for the final use of the made land at the CDF site at project completion.

- Agreements with adjacent landowners for access or other potential interactions inherent in the construction and operation of a CDF.

- The role of recent precedent and flexibility for remedial purposes in determining State acceptance of a CDF in the region.

- Mitigation for the loss of benthic habitat at the CDF location.

- Obtaining the required regulatory approvals and permits.

A detailed evaluation of siting considerations associated with the construction of a nearshore CDF is presented in Appendix H of the FFS [Malcolm Pirnie, Inc., 2008 (anticipated)].

The presence of the Newark Bay CDF near Elizabeth Channel demonstrates that the option of using a CDF in New York Harbor is implementable. The Newark Bay CDF was constructed in 1997 for sediments generated as a result of navigational dredging; however, recent usage has been limited to emergency projects or projects with a demonstrated hardship (*i.e.*, other cost-feasible options are not available).

<u>Upland Processing Facility Siting</u>: An upland processing facility would be required for alternatives in which off-site or regional treatment of dredged material are incorporated.

For alternatives involving off-site treatment and disposal (Alternatives 3, 6, and 9), the upland processing facility would consist of several components. Dredged material that has been hydraulically offloaded from the scow would be dewatered using geotextile bags at the upland facility. Because the use of existing treatment facilities may not be sufficient to treat all of the contaminated sediments targeted for removal under these alternatives [Appendix H of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], it was assumed that temporary storage would need to be provided at the upland processing facility to store materials awaiting off-site processing. Water treatment operations to handle dewatering water and stormwater would also be located at the facility.

For alternatives involving decontamination and beneficial use (*i.e.*, regional thermal treatment; Alternatives 4, 7, and 10), dredged material would be dewatered as described above and moved to the thermal treatment area at the upland facility for additional processing. These alternatives rely on the construction and operation of a self-contained thermal treatment facility. Because thermal plant throughput capacities would not be able to keep up with remedial dredging associated with Alternatives 4 and 10 [Appendix H of the FFS; Malcolm Pirnie, Inc., 2008 (anticipated)], dredged material storage areas at the upland processing facility would be required. No storage is anticipated to be required for Alternative 7. Water treatment operations to handle dewatering water and stormwater would also be located at the facility.

Thorough siting studies would be required during the design phase of the Source Control Early Action to identify suitable site locations for the construction of an upland processing facility for these alternatives.

Technical issues related to the siting of an upland processing facility include the following:

- The need for an extensive data collection program to identify and evaluate potential sites for the facility; the program would include evaluations of site geology, evaluations of local community needs, evaluation of the current land use at the potential facility sites and adjacent properties, and other relevant analyses.

- The design and construction of a regional thermal treatment facility (for Alternatives 3, 6, and 9).

- An evaluation of feasible throughput capacities and storage requirements associated with off-site or regional thermal treatment of dredged material. This evaluation would also include an assessment of the availability of off-site treatment facilities (for Alternatives 3, 6, and 9) to dedicate a portion of their annual operations to the Lower Passaic River.

Policy issues related to the siting of an upland processing facility include the following:

- Willingness of the community to host such a facility.

- Agreements with adjacent landowners for access or other potential interactions inherent in the construction and operation of an upland processing facility.

- The role of recent precedent and flexibility for remedial purposes in determining State acceptance of a regional thermal treatment plant (for Alternatives 4, 7, and 10).

- Obtaining the required regulatory approvals and permits.

A detailed evaluation of siting considerations associated with the construction of an upland processing facility is presented in Appendix H of the FFS [Malcolm Pirnie, Inc., 2008 (anticipated)].

B.14 COST INFORMATION

The total cost for each alternative has been estimated based on capital costs and O&M costs, and are presented in Table B.14-1. The actual costs will vary depending on the specifications contained in the detailed remedial design. Further, the actual costs will also vary because the cost estimates provided are developed conservatively and have an accuracy of +50 percent to -30 percent, in compliance with USEPA guidance (USEPA, 1988).

Table B.14-1: Cost Estimates for Remedial Alternatives

Alternative	Total Capital Costs	Total DMM Costs	Annual O&M Costs	Total O&M Costs	Total Present Worth Costs
Alternative 1: No Action					
Alternative 2: Dredging with CDF Disposal					
Alternative 3: Dredging with Off-Site Treatment and Disposal					
Alternative 4: Dredging with Decontamination and Beneficial Use					
Alternative 5: Capping with CDF Disposal					
Alternative 6: Capping with Off-Site Treatment and Disposal					
Alternative 7: Capping with Decontamination and Beneficial Use					
Alternative 8: Capping with Navigation and CDF Disposal					
Alternative 9: Capping with Navigation and Off-Site Treatment and Disposal					
Alternative 10: Capping with Navigation and Decontamination and Beneficial Use					

B.14.1 Capital Costs

Capital costs have been estimated for pre-construction activities (includes investigation and design), mobilization/demobilization, dredging, backfilling or capping, testing and monitoring during dredging and capping activities, and dredged material management (DMM). The capital costs also include an additional 8 percent of the cost of field activities for construction management services and an additional 20 percent for contingency.

Alternatives which would remove the entire inventory of contaminated sediment in the Area of Focus (and therefore involve the largest dredging volume) are significantly more costly than alternatives which would utilize a combination of capping and pre-dredging (and therefore incorporate smaller volumes of sediment removal). For the capping alternatives, although capping costs are higher than dredging costs, the cost of dredging is still a significant part of the capital cost for these alternatives.

Capital costs are most influenced by the DMM scenario of a given alternative. There are three different DMM scenarios: CDF disposal; off-site treatment and disposal; and decontamination and beneficial use.

Alternatives that utilize a CDF as means of final disposal are the most economical to construct. However, a CDF requires additional O&M compared to the other alternatives. Alternatives that involve off-site treatment and disposal of the dredged sediment are significantly more costly than other alternatives (*i.e.*, CDF disposal and on-site decontamination for beneficial use) due to costs associated with off-site transportation of the dredged material.

B.14.2 Operations and Maintenance Costs

Annual O&M costs have been estimated for bathymetric surveys, surface sediment, water column and groundwater sampling and analysis, biological monitoring, habitat recolonization surveys, cap maintenance, and community outreach. Based on USEPA guidance, costs are included for a period of thirty years of monitoring for each alternative (USEPA, 1988); however, a longer timeframe may apply for cap maintenance. The present-worth of the annual O&M costs (total O&M costs) were calculated using a discount rate of 5 percent and a 30-year time interval.

The major cost drivers are surface sediment sampling and analysis, biological monitoring and cap maintenance. While surface sediment sampling and analysis and biological monitoring costs are high, they are equal for all alternatives; however, O&M costs due to cap maintenance vary from one alternative to another. Alternatives which employ an engineered cap over a greater area require more significant O&M costs. In addition, O&M activities would be performed with less frequency (*i.e.* every five years) for alternatives that remove the entire inventory of contaminated sediment. Alternatives which involve CDF disposal require additional operations and maintenance costs for crust management and monitoring beyond the remedial alternative implementation period.

Finally, while O&M costs are higher for alternatives which utilize an engineered cap, the capital costs associated with DMM drive the total cost of alternatives which involve greater quantities of dredging. Alternatives involving capping achieve the same mass remediation and risk reduction as alternatives involving greater quantities of dredging for significantly lower total cost.

Because these alternatives would result in some contaminants remaining on-site above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

B.15 LETTERS FROM STAKEHOLDERS AND STATE

To be addressed.

Acronyms

2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzodioxin
AE/WP	American eel and white perch
AOC	Administrative Order of Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AT	Averaging Time
ATSDR	Agency for Toxic Substance and Disease Registry
BAF	Bioaccumulation Factor
BDA	Brownfield Development Area
Be-7	Beryllium-7
CAD	Confined Aquatic Disposal
CBR	Critical Body Residue
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMB	Chemical Mass Balance
COPC	Contaminant of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
CPG	Cooperating Party Group
Cs-137	Cesium-137
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CSTAG	Contaminated Sediment Technical Advisory Group
CTE	Central Tendency Exposure
CWA	Clean Water Act

cy	cubic yard
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
Total DDT	Sum of DDD, DDE, and DDT isomers
DMM	Dredged Material Management
EFH	Exposure Factors Handbook
EMB	Empirical Mass Balance
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FC	Future Conditions Assumption
FFS	Focused Feasibility Study
f/k/a	formerly known as
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMW	High Molecular Weight
HQ	Hazard Quotient
HRC	High Resolution Core
H:V	Horizontal:Vertical
IRIS	Integrated Risk Information System
LMW	Low Molecular Weight
LOAEL	Lowest Observed Adverse Effect Level
LWA	Length-Weighted Average
M	Modeling Assumption
mg/kg	milligram per kilogram
mg/kg-day	milligram per kilogram per day
mg/L	milligram per liter
MLW	Mean Low Water

MNR	Monitored Natural Recovery
NA	Not Available
NCP	National Contingency Plan
ND	Not Determined
ng/g	Nanogram per Gram
ng/kg	Nanogram per Kilogram
NHPA	National Historic Preservation Act
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJPDES	New Jersey Pollutant Discharge Elimination System
N.J.S.A.	New Jersey Statues Annotated
NJTPA	New Jersey Transportation Planning Authority
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priority List
NRRB	National Remedy Review Board
O&M	Operations & Maintenance
OCC	Occidental Chemical Corporation
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PATH	Port Authority Trans Hudson
PCB	Polychlorinated Biphenyl
PCDD/F	Polychlorinated Dibenzodioxins/Furans
POTW	Publicly Owned Treatment Works
PPT	Parts per Thousand
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party

PRSA	Passaic River Study Area
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Oral Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SP	System Process Assumption
SPMD	Semi-permeable Membrane Device
ST	Source Term Assumption
SWO	Stormwater Outfall
TBC	To Be Considered
TCDD	Tetrachloridibenzodioxin
TCLP	Toxicity Characteristic Leaching Procedure
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalent (Concentration)
TOC	Total Organic Carbon
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
μg/g	microgram per gram
μg/kg	microgram per kilogram
USACE	United States Army Corps of Engineers
U.S.C.	United States Code

USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WHO	World Health Organization
WRDA	Water Resources Development Act

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